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WITH A

CONSIDERABLE NUMBER OF TABLES,

Expreſſing the Elective Attractions, Specific Gravities, Comparative Heats, Component Parts, Combinations, and other Affections of the Objects of Chemical Reſearch.

ILLUSTRATED WITH ENGRAVINGS.

By WILLIAM NICHOLSON.

IN TWO VOLUMES.

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Refining and cupellation of the ſilver.

The amalgams, according to their coppery or leady appearance, or to their purity, are either refined by cupellation, or ſimply melted down, and run into ingots.

When containing no gold, they may be delivered to the mint, without further fuſion or cupellation, notwithſtanding their copper alloy; but if auriferous and coppery, then they muſt be refined, or put to cupellation, that the copper may be deſtroyed, and the auriferous ſilver be brought to the ſtandard of 15 loth 15 grains *per marc*, in which it is received at the mint.

Diſtillation of the quickſilver, ſeparated from the amalgam by heat or preſſure.

The quickſilver, ſeparated by heat from the amalgam, contains ſome of the noble metals which paſſed with it through the preſſing-bag. This generally amounts to 3—4, or one ounce per cwt. But this quickſilver being conſtantly in hand, and always ſerving in the ſubſequent triturations, its contents of gold and ſilver need only to be aſcertained once at the annual balance of the accounts. This may be done, in ſmall aſſays, by diſtilling the quickſilver, with granulated lead, in glaſs retorts; but the operation ſucceeds beſt in tubulated iron retorts, with caſt iron receivers, filled with water, and luted to the necks of the retorts. Each of theſe is ſunk half into the furnace, with its neck much inclined into the receivers. They are filled with two cwt. of quickſilver, to which is added 1—2, or one pound of granulated lead. The tubulated opening of the retort, and the neck of the receiver, muſt be carefully luted with refractory clay. The fire ſhould be briſk, and the whole body of the retort be covered with the burning fuel. The quickſilver riſes up in the form of vapour, and paſſes over into the receiver, where it is condenſed, collected into drops, and falls to the bottom of the water. All the auriferous ſilver remains behind united with the lead, which, if it ſhould ſtick to the bottom of the retort, may be melted in it by a coal-fire, and poured out into an ingot, to be afterwards put to the teſt or cupellation.

Further treatment and uſe of the triturated reſidua, which have gon ethrough the proceſs of amalgamation.

The reſidua commonly contain ſome gold and ſilver, more or leſs, according as they were well or badly pulverized, calcined, ſifted, triturated, and waſhed. If the reſiduum ſhould contain more than one ounce per cwt. and raw uncalcined particles appear in the ſame, it will be adviſeable to calcine it once more with an addition of four per cent. of ſalt, and to let it undergo a ſecond amalgamation. If it ſhould be of an equal ſize, and perfectly calcined, it ſhould be mixed up with new ſtuff, or triturated once more alone.

If, on the contrary, the reſiduum is ſilvery, in conſequence of the imperfect waſhing and ſeparation of the quickſilver and amalgam, it muſt be waſhed over again, more abundantly diluted with water.

The lixivia containing copper are precipitated by iron.

The Editors of the Chemical Journal add the following remarks, in a note, on the cold amalgamation:

Conſidering the complex apparatus for the warm amalgamation, the wear and loſs of the copper boilers, the unequal produce, and the expence of firing (all which are now avoided), the cold amalgamation is, as Mr. Raſpe obſerves, a noble improvement of the proceſs. It was what Baron Born always aimed at, though his attempts were unſucceſsful. Mr. Gellert, at Freyberg, firſt ſucceeded in it, uſing wooden cylindrical churns with perpendicular piſtons, laid over with copperſheeting, which, by a quick motion up and down, produce a ſtronger trituration than the rotatory horizontal motion of barrels, and at the ſame time prevents the poſſibility of producing ſublimate, or mercurius dulcis, by the exceſs of marine acid acting upon the quickſilver, to which that acid has leſs affinity than to copper. His firſt experiment was attended with uncommon ſucceſs; for, by cold churning, he extracted the ſilver from pulveriſed ore, which contains but three ounces and a quarter per quintal, in the courſe of 16 hours, ſo completely that the leavings contained but two dwts. (The operation may even be finiſhed in 10 hours, which otherwiſe required 24). Upon theſe principles the churning apparatus, in wooden cylinders, has been adopted in Bohemia, with a perforated caſt iron piſton, which by a crank motion moves quickly up and down. Though the whole is put in cold, yet, at the end of the operation, it heats in conſequence of the quick trituration and motion of the piſtons.

At Freyberg this cold amalgamation is performed in a mill which turns eight large barrels, each holding 10½ quintals of ore: The ores are dreſſed to contain four ounces per quintal, mixed with 10 per cent. of ſalt, and calcined and ſifted in Baron Born's manner. When put into the barrels, one-fourth per cent. of quick-lime, and 34 lbs. of water are added, and turned briſkly two hours, 36 turns per minute. The lime abſorbs the exceſs of acids. To counteract the decompoſition of metallic vitriols, and the precipitation of ſilver particles (which an exceſs of lime might occaſion), after two hours turning, two per cent. of thin rolled iron chips, two inches ſquare, are thrown into the barrels, and turned with the ſame two hours. Then the quickſilver, half a quintal to one quintal of ore, is added, together with an additional four per cent. of iron chips, previouſly coated with a little copper, by immerſion in copper water, in order to prevent the diſperſion of the quickſilver, and to catch and attract its ſmalleſt particles. After theſe laſt coppery-iron chips and the quickſilver have been added, the barrels are turned ſlower, at the rate of 20 or 25 turns per minute. After 12 hours turning, all the ſilver is extracted, except 1¼ dwt. per quintal, which cannot be further extracted by amalgamation.

ORES OF IRON. When we conſider the great deſtructibility of iron by the diſengaged acids, and other uncombined agents in nature; it is not to be expected that much native iron ſhould be found. We have however indubitable accounts of its exiſtence. The moſt remarkable maſs of this ſort was diſcovered in Siberia, by Profeſſor Pallas, which weighed 1600 pounds. Specimens of this have been ſent to all parts of Europe. It is of that ſpecies called red ſhort, being malleable while cold, but brittle when red hot.

It can hardly be doubted, but that this great maſs of iron, brought by Pallas from Siberia into Europe, is the produce of nature. Its compoſition reſembles that of forged iron; for a centenary (= 63 grains) yielded Bergman, by means of the muriatic acid, 49 cubic inches of inflammable air; and from many experiments it is found that ductile iron yields from 48 to 51 of the ſame inches *.

Margraff, quoted by Fourcroy, found ſome of this kind of iron, in the form of ridges, at Ebenſtock (or Eibenſtock) in Saxony.

Native iron has been found, in a cubical form, at Senegal in Africa, out of which the black inhabitants make various veſſels for their own uſe; alſo at

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* Magellan, in conſequence of having examined this ſpecimen of native iron, gives it as his opinion that it is a real volcanic production; but Profeſſor Pallas expreſsly obſerves (Journal de Phyſique, Supplement, tom. xiii. for 1778, p. 128.) that the country where it was found affords not the leaſt volcanic indication.

Eibenſtock, on the margravate of Miſnia, in the Upper-Saxony, and at Stiria, in the circle of Auſtria. Some native irons have been found in a polyedral granulated form, and of a bright yellow colour, which on being poliſhed ſhew their proper metallic colour; theſe two ſpecies of native iron are mentioned by Wallerius, in his Spec. 321.

Monet, quoted by Mongez, mentions a piece of many pounds weight, that has all the qualities of a good iron, and is kept in the collection of the College of the Mines at Freyberg. Other ſpecimens have been found alſo of the kind near Bareith, which were malleable: and, laſtly, the ſame Mongez mentions three ſpecimens of native iron, kept in the King's cabinet in the Royal Garden at Paris; one of which was found at Kaumsdorf, in Thuringia; this is ſurrounded by an ore of the hepatic iron, and has a cavity with ſome protuberances of a brown hematites. The other two are from the native iron found by Pallas on the Emir Mountains of Siberia.

Bergman conſiders miſpickel as a mixture of native iron and arſenic. For a deſcription of this ore, ſee Mispickel. It is called Pierre de Santé by the French, but for what reaſon I know not, and is cut for toys. Twenty or thirty years ago a mineral was in common uſe for this purpoſe in England. The ſmall ſtones or pieces were called marcaſites, and were, I ſuppoſe, miſpickel.

Wolfram is enumerated among iron ores, though never wrought as ſuch. Meſſ. De Luyarts found only $13\frac{1}{4}$ per cent. of iron. See Wolfram.

The magnet, or loadſtone, is an ore containing iron approaching to the metallic ſtate. It has not been much examined, probably on account of the heterogeneous nature of the various ſtones called by this name. Magnetiſm is their characteriſtic property, but they may nevertheleſs differ exceedingly in their contents, ſo as ſcarcely to come under the ſame mineralogical arrangement. Some contain as much as 75 per cent. of iron. See Loadstone, Magnet, and Magnetism.

The black iron ore, or ſteel ore, is ponderous, of a very dark-gray colour, or rather ſlate black, and affords a black powder when ſcraped. Some ſpecimens, however, afford a red powder. It is readily attracted by the magnet. Its fracture exhibits grains more or leſs fine, or elſe ſcales or facets, whence it has been improperly called galena of iron. When expoſed to heat it gives ſcarcely any ſmell, and changes its colour very little, though its ſhining appearance goes off. A ſtrong heat renders it partly malleable. It gives fire with ſteel, in conſequence of a proportion of quartz it contains. Acids act upon it to a certain degree, but the iron is too much calcined to afford many cryſtals with the vitriolic acid.

That ſpecies of black iron ore, which has the form of octahedrons, nearly reſembles the foregoing in its properties.

The calciform ores of iron are in general conſidered to be formed by depoſition. Mongez reduces them to ſix principal ſpecies: 1. Ochres. 2. Earthy or bog ores. 3. Cryſtallized ore of the Iſle of Elba. 4. Hematites. 5. Specular iron ore, and 6. Emery.

The ochres are very common, and appear to have been produced by the decompoſition of pyrites; ſee Ochres. There are two varieties: 1. Yellow ochre: this becomes red by calcination. 2. Red ochre. Both theſe are ſo common, and ſo much uſed in the arts, that it is ſcarcely requiſite to deſcribe the great variations of colour and conſiſtence the ſeveral ſpecimens poſſeſs.

Earthy, argillaceous, or bog ores of iron, are of different colours, reddiſh, yellowiſh brown, and ſometimes gray, eſpecially after expoſure to the air for a time. Internally they have a blueiſh-gray or iron colour. This ore is brittle, and reſembles ſcoriæ, or ſmall rounded or flattened ſtones, not obedient to the magnet, and in general of inconſiderable hardneſs. It moſtly abounds with foreign ſandy argillaceous or calcareous matters.

The cryſtallized iron ore of the iſland of Elba is one of the moſt beautiful of minerals. It has not yet been found except in that iſland. It is found in different ſtates, in ochres of every ſhade, in the argillaceous ſandy ore, in cryſtallized ore, and in hematites. The cryſtallized is the moſt common, the pureſt, and moſt beautiful. Its form, as well as colour, varies much. The ſhades are green, red, black, yellow, brown, blue, and violet; and ſome exhibit all the various and lively colours of precious ſtones, though this brilliant appearance becomes tarniſhed by the moiſture of the air. This ore is very ponderous and hard, and frequently mixed with copper pyrites. Acids do not attack it, neither is it affected by the magnet, at leaſt while in the maſs: I do not find that this ore has been well analyſed. Some writers pretend that ſulphur is the mineralizer, and others fixed air; but from its great reſemblance to the combination of iron with water in the experiment of the gun barrel (ſee AIR INFLAMMABLE), it appears likely that that fluid, as one of its principles, enters into the iron ore of the Iſle of Elba.

Hematites exiſts in conſiderable abundance in the iron mines of ancient formation. It is formed in the manner of ſtalactites and ſtony concretions. In general it poſſeſſes conſiderable hardneſs, ſo as ſometimes to give fire with ſteel. The varieties are, 1. Blackiſh hematites; fracture, vitreous, and ſometimes ſhining; texture, fibrous or ſtriated; colour brown black, but reddiſh when pounded. It gives fire with ſteel, becomes darker coloured, and as it were ſcaly, by ignition.—2. Red hematites. This is chiefly entitled to the name of blood-ſtone, from its colour. It is very heavy, ponderous, ſtriated, and as if cryſtallized, or in ſmall globules, called kidney ore.—3. Yellow hematites. This differs from the preceding, from the degree of the calcination of its metallic part, in the ſame manner as yellow ochre differs from red.

The ſpecular iron ore, mentioned by Mongez among the calciform ores of iron, is eaſily diſtinguiſhed by its brilliant facets, which often reſemble poliſhed ſteel. It is diſtinguiſhed from the iron ore of Elba by a ſmall portion of ſulphur which it contains. It is plentifully found at Mount D'Or in Auvergne.

Emery is an ore of iron, which has the appearance of a very compact granular ſtone, of a blackiſh, grayiſh, or brown colour. By calcination it becomes brown or red, and, as Mongez ſays, harder than before. Kirwan thinks it to be a mixture of the red and white calces of iron with ſome unknown ſtony ſubſtance, perhaps tripoli. It is uſed as a grinding and poliſhing powder, and is ſcarcely inferior in hardneſs to any ſubſtance but the diamond. Its ſpecific gravity is from 3,008 to 4,000. The beſt ſort is of a dark gray colour. It is never wrought as an iron ore.

The white or ſparry iron ore, or ſtahlſtein of the Germans, conſiſts, according to Bergman, of the brown calx of iron united with the white calx of manganeſe, and mild calcareous earth, in various proportions. Bayen * examined a ſpecimen from Germany of the beſt ſteel ore, and found it contain two-thirds iron, and the reſt fixed air, except a ſmall portion of zinc. The figure of this ore is either irregular or rhomboidal; frequently tranſparent; its texture ſcaly, lamellar, granular, or cellular. Sometimes it poſſeſſes a ſtalactitical form,

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* Journal de Phyſ. vii. 213. As this chemiſt did not reduce his iron beyond the ſtate of a magnetical powder, I think he overlooked the nickel, which is magnetical, like iron, and alſo affords a green ſalt with vitriolic acid.

and is ſometimes found in blackiſh brown powder. Its colour, when freſh dug, is whitiſh, but by expoſure to the air it becomes gray, brown, reddiſh, yellowiſh, or black. Its ſpecific gravity is from 3.6 to 4.0. It does not give fire with ſteel, unleſs by virtue of particles of quartz or pyrites, with which it is frequently interſperſed. In the fire it decrepitates, grows black, becomes magnetic, and loſes about one-third of its weight by the extrication of fixed air. One hundred parts of this ore from Eiſenartz, in Stiria, afforded Bergman 38 of the brown calx of iron, 24 of the white calx of manganeſe, and 38 of mild calcareous earth. The iron anſwering to this quantity of calx is about 32 parts or one-third of the whole.

Iron mineralized by ſulphur is moſtly diſtinguiſhed by the name of pyrites. It ſeldom contains iron in ſufficient quantity to be extracted with profit, not only becauſe a long continued heat is required to drive off the laſt portions of ſulphur, but likewiſe becauſe the iron uſually proves of a bad quality. This ore has various degrees of hardneſs and conſiſtency; is of a pale yellow colour, ſometimes approaching that of gold, a circumſtance which, added to its conſiderable weight, often attracts the attention of the unſkilful, who imagine it to contain gold. It gives plenty of ſparks with the ſteel, and emits an odour of ſulphur. In the fire it cracks or decrepitates, burns with a blue flame, and aſſumes a dull brown colour: in the air it effloreſces, is decompoſed, its ſulphur becomes acidified, unites with the iron and clay which are preſent in its compoſition, and with theſe forms vitriol and alum, for the obtaining both of which this mineral is wrought. Its varieties are, 1. In irregular maſſes. 2. In balls of various ſizes diſſeminated in chalk. 3. In ſtalactites. 4. In cubes, frequently found in clay. 5. In hard cryſtals called marcaſite.

The brown or reddiſh-brown ferruginous pyrites is called the hepatic iron ore. It is either ſpherical, or in cubes, or other regular forms: has no metallic luſtre, does not eaſily give fire with ſteel, and is incapable of vitriolization. It contains much leſs ſulphur and more iron than the yellow pyrites, but the metal it yields is brittle.

Gray iron ore has a ſhining metallic appearance, and commonly gives fire with ſteel. It is not at all magnetic, and, when ſcratched, gives a red trace. It yields from 40 to 66 per cent. of cold ſhort iron. This property is derived from phoſphorus, or its acid, which exiſts in the ore.

There are two ores of iron which contain plumbago united with iron. One is ſhining black, of a ſcaly texture, and more or leſs magnetic, called black Eiſen Rahm or glimmer, by the Germans: the other is red, and differs from the preceding only in not being magnetic before calcination.

A blue combination of iron is found interſperſed in clays in Finland, Scania, and elſewhere. Bergman calls it Native Pruſſian Blue. Sometimes the clays have a blue colour at their ſurface, and ſometimes they aſſume that colour ſoon after being dug out of the ground. It is eaſily ſeen that the ore is ferruginous, and highly loaded with combuſtible matter; for it burns with a flame, and becomes red and magnetical. A mild heat renders this ſubſtance green, and a ſtronger converts it into black ſcoria. Alkalis, as well as acids, diſſolve this blue powder, and deſtroy its colour, which nevertheleſs appears again when precipitated from an acid by an alkali, or by an alkali from an acid; but commonly it is greeniſh, and ſoon becomes white. If an infuſion of tea or nut galls be poured on this whitiſh ſediment, it reſumes its firſt colour. From theſe details it appears, as Bergman remarks, that this blue, though analogous to the artificial Pruſſian blue, differs nevertheleſs from it in intenſity, by the manner of its production and other peculiar qualities. It preſerves its colour in water, but becomes black in oils.

For the methods of analyſis of the ores of iron, as well as its chemical properties and ſeveral ſtates, ſee the article Iron. But from the extenſive importance of this metal, I ſhall here add the methods of treatment in the large way, from Keir's notes to Macquer's Dictionary, article Smelting.

Moſt ores of iron require to be roaſted previouſly to their fuſion; ſome more ſlightly, and others with a more violent and longer continued fire. Thoſe which contain much ſulphur, arſenic, or vitriolic acid, require a long continued and repeated roaſting, that the volatile matters may be expelled. Of this kind is the black iron ore, from which the Swediſh iron is ſaid to be obtained.

Some ores require a very ſlight roaſting, only that they may be dried and rendered friable; ſuch are the ores called bog ores: and others, which being in a calcined ſtate, and containing little ſulphureous matter, would, by a further calcination, be rendered leſs capable of being reduced to a metallic ſtate.

The roaſting of ores of iron is performed by kindling piles, conſiſting of ſtrata of fuel and of ore placed alternately upon one another, or in furnaces ſimilar to thoſe commonly employed for the calcination of lime-ſtone.

The next operation is the fuſion or ſmelting of the ore. This is generally performed in furnaces or towers from 20 to 30 feet high, in the bottom of which is a baſon for the reception of the fluid metal. When the furnace is ſufficiently heated, which muſt be done at firſt very gradually, to prevent the cracking of the walls; a quantity of the ore is to be thrown in, from time to time, at the top of the furnace, along with a certain quantity of fuel and of lime-ſtone, or whatever other flux is employed. While the fuel below is conſumed by the fire excited by the wind of the bellows, the ore, together with its proportionable quantity of fuel and of flux, ſink gradually down, till they are expoſed to the greateſt heat in the furnace. There the ore and the flux are fuſed, the metallic particles are revived by the fuel, are precipitated by means of their weight through the ſcoria formed of the lighter earthy parts of the flux and of the ore, and unite in the baſon at the bottom of the furnace, forming a maſs of fluid metal covered by a glaſſy ſcoria. When a ſufficient quantity of this fluid metal is collected, which is generally twice or thrice in 24 hours, an aperture is made, through which the metal flows into a channel or groove made in a bed of ſand; and from thence into ſmaller lateral or connected channels, or other moulds. There it is cooled, becomes ſolid, and retains the forms of the channels or moulds into which it flows. The piece of iron formed in the large channel is called a ſow, and thoſe formed in the ſmaller channels are called pigs. Sometimes the fluid iron is taken out of the furnace by means of ladles, and poured into moulds, ready prepared, of ſand or of clay, and is thus formed into the various utenſils and inſtruments for which caſt iron is a proper material.

The ſcoria muſt be from time to time allowed to flow out, when a conſiderable quantity is formed, through an aperture made in the front of the furnace for that purpoſe. A ſufficient quantity of it muſt, however, be always left to cover the ſurface of the melted iron; elſe the ore which would fall upon it, before the ſeparation of its metallic from its unmetallic parts, would leſſen the fluidity and injure the purity of the melted metal. This ſcoria ought to have a certain degree of fluidity; for if it be too thick, the revived metallic particles will not be able to overcome its tenacity, and collect together into drops, nor be precipitated.

Accordingly, a ſcoria, not ſufficiently fluid, is always found to contain much metal. If the ſcoria be too thin, the metallic particles of the ore will be precipitated before they are ſufficiently metallized, and ſeparated from the earthy and unmetallic parts. A due degree of fluidity is given to the ſcoria, by applying a proper heat, and by adding fluxes ſuited to the ore.

Some ores are fuſible without addition, and others cannot be ſmelted without the addition of ſubſtances capable of facilitating their fuſion.

The fuſible ores are thoſe which contain ſulphur, arſenic, or are mixed with ſome fuſible earth.

The ores difficultly fuſible are, thoſe which contain no mixture of other ſubſtance. Such are moſt of the ores which contain iron in a ſtate nearly metallic. As iron itſelf, when purified from all heterogeneous matters, is ſcarcely fuſible without addition, ſo the metal contained in theſe purer kinds of ores cannot be eaſily extracted without the addition of ſome fuſible ſubſtance. 2. Thoſe which are mixed with ſome very refractory ſubſtance. Some of theſe refractory ores contain arſenic; but as this ſubſtance facilitates the fuſion of iron, we may preſume that their refractory quality depends upon a mixture of ſome unmetallic earth or other unfuſible ſubſtance. The earth which is mixed with the common calciform ores is in conſiderable quantity, and is ſometimes calcareous, ſometimes ſiliceous, and ſometimes argillaceous.

Keir thinks it probable that the fuſibility of ſome ores may greatly depend on the degree of calcination to which the metal contained in them has been reduced; ſince we have reaſon to believe, that, by a very perfect calcination, ſome metals, at leaſt, may be reduced to the ſtate of an earth almoſt unfuſible, and ſcarcely capable of reduction; and ſince we know, that in every calcination and ſubſequent reduction of a given quantity of any imperfect metal, a perceptible part of that quantity is always loſt or deſtroyed, however carefully theſe operations may have been performed. That ſome of theſe ores are already too much calcined, appears from the inſtance above-mentioned of the bog ores, which are injured by roaſting; and even the great height of the common ſmelting furnaces, although advantageous to many ores that require much roaſting, is ſaid to be injurious to thoſe which are already too much calcined, by expoſing them to a further calcination, during their very gradual deſcent, before they arrive at the hotteſt part of the furnace, where they are fuſed.

But, as too violent calcination renders ſome ores difficultly fuſible; ſo, too ſlight calcination of other ores injures the purity of the metal, by leaving much of the ſulphureous or other volatile matter, which ought to have been expelled.

Various ſubſtances are added to aſſiſt the fuſion of ores difficultly fuſible. Theſe are: 1. Ores of a fuſible quality, or which being mixed with others of a very different quality, become fuſible: accordingly in the great works for ſmelting ores of iron, two or more different kinds of ores are commonly mixed, to facilitate the fuſion, and alſo to meliorate the quality of the iron. Thus an ore yielding an iron which is brittle when hot, which quality is called red-ſhort, and another ore which produces iron brittle when cold, or cold-ſhort, are often mixed together; not, as is ſometimes ſuppoſed, that theſe qualities are mutually deſtructive of each other, but that each of them is diminiſhed in the mixed maſs of iron, as much as this maſs is larger than the part of the maſs originally poſſeſſed of that quality. Thus, if from two ſuch ores the maſs of iron obtained conſiſts of equal parts of cold-ſhort and of red-ſhort iron, it will have both theſe qualities, but will be only half as cold-ſhort as iron obtained ſolely from one of the ores, and half as red-ſhort as iron obtained only from the other ore. 2. Earths and ſtones are alſo generally added to facilitate the fuſion of iron ores. Theſe are ſuch as are fuſible, or become fuſible when mixed with the ore, or with the earth adhering to it. Authors direct, that, if this earth be of an argillaceous or ſiliceous nature, limeſtone or ſome calcareous earth ſhould be added; and that if the adherent earth be calcareous, an argillaceous or ſiliceous earth ſhould be added; becauſe theſe two earths, though ſingly unfuſible, yet, when mixed, mutually promote the fuſion of each other: but as lime-ſtone is almoſt always added in the ſmelting of iron ores, and as in ſome of theſe, at leaſt, no argillaceous or ſiliceous earth appears to be contained, Keir is inclined to believe, that it generally facilitates the fuſion, not merely by uniting with thoſe earths, but by uniting with that part of the ore which is moſt perfectly calcined, and leaſt diſpoſed to metallization; ſince we know, that by mixing a calciform or roaſted ore of iron with calcareous earth, without any inflammable matter, theſe two ſubſtances may be totally vitrified. See Experiments made upon Quick-lime, and upon Iron, by Mr. Brandt, in the Swediſh Memoirs for the years 1749 and 1751. Calcareous earth does indeed ſo powerfully facilitate the fuſion of iron ores, that it deſerves to be conſidered whether workmen do not generally uſe too great a quantity of it, in order to haſten the operation. For when the ſcoria is rendered too thin, much earthy or unmetallized matter is precipitated, and the caſt iron produced is of too vitreous a quality, and not ſufficiently approximated to a true metallic ſtate.

Some authors pretend, that a principal uſe of the addition of lime-ſtone in the ſmelting of iron ores is to abſorb the ſulphur, or vitriolic acid, of theſe ores: but, as we have already obſerved, a hepar of ſulphur is formed by that mixture of calcareous earth and ſulphur, which is capable of diſſolving iron in a metallic ſtate; and thus the quantity of metal obtained from an ore not ſufficiently diveſted of its ſulphur, or vitriolic acid, (which, by uniting with the fuel, is formed into a ſulphur during the ſmelting) muſt be conſiderably diminiſhed, though rendered purer by addition of calcareous earth: hence the utility appears, of previouſly expelling the ſulphur and vitriolic acid from the ore by a ſufficient roaſting. 3. The ſcoria of former ſmeltings is frequently added to aſſiſt the fuſion of the ore; and when the ſcoria contains much iron, as ſometimes happens in ill-conducted operations, it alſo increaſes the quantity of metal obtained.

The quantity of theſe fuſible matters to be added, varies according to the nature of the ore; but ought in general to be ſuch, that the ſcoria ſhall have its requiſite degree of thinneſs, as is mentioned above.

The fuel uſed in moſt parts of Europe for the ſmelting of ores of iron is charcoal. Lately, in ſeveral works in England and Scotland, iron ore has been ſmelted by means of pit-coal, previouſly reduced to cinders or coaks, by a kind of calcination ſimilar to the operation for converting wood into charcoal, by which the aqueous and ſulphureous parts of the coal are expelled, while only the more fixed bituminous parts are left behind. In France, pit-coal not calcined has been tried for this purpoſe, but unſucceſsfully. The uſe of peat has alſo been introduced in ſome parts of England.

The quality of the iron depends conſiderably upon the quality, and alſo upon the quantity of the fuel employed. Charcoal is fitter than coaks for producing an iron capable of being rendered malleable by forging.

The quantity of fuel, or the intenſity of the heat, muſt be ſuited to the greater or leſs fuſibility of the ore. Sulphureous and other ores eaſily fuſible require leſs fuel than ores difficultly fuſible. In general, if the quantity of fuel be too ſmall, and the heat not ſufficiently intenſe, all the iron will not be reduced, and much of it will remain in the ſcoria, which will not be ſufficiently thin. This defect of fuel may be known by the blackneſs and compactneſs of the ſcoria, by the qualities of the iron obtained, which in this caſe is hard, white, light, intermixed with ſcoria, ſmooth in its texture, without ſcales or grains, rough and convex on its ſurface, and liable to great loſs of weight by being forged; and laſtly, it may be known by obſerving the colour and appearance of the drops of metal falling down from the ſmelted ore, and of the ſcoria upon the ſurface of the fluid metal, both which are darker coloured than when more fuel is uſed. When the quantity of fuel is ſufficiently large, and the heat is intenſe enough, the iron is darker coloured, denſer, more tenacious, contains leſs ſcoria, and is therefore leſs fuſible, and loſes leſs of its weight by being forged. Its ſurface is alſo ſmoother and ſomewhat concave; and its texture is generally granulated. The ſcoria in this caſe is of a lighter colour and leſs denſe. The drops falling from the ſmelting ore, and the liquid ſcoria in the furnace, appear hotter and of a brighter colour. When the quantity of fuel is too great, and the heat too intenſe, the iron will appear to have a ſtill darker colour, and more conſpicuous grains or plates; and the ſcoria will be lighter, whiter, and more ſpongy. The drops falling from the ſmelted ore, and the fluid ſcoria, will appear to a perſon looking into the furnace through the black hole to be very white and ſhining hot. The quantity of charcoal neceſſary to produce five hundred weight of iron, when the ore is rich, the furnace well contrived, and the operation ſkilfully conducted, is computed to be about forty cubic feet; but is much more in contrary circumſtances.

The time during which the fluid metal ought to be kept in fuſion before it is allowed to flow out of the furnace, muſt be alſo attended to. In ſome works the metal is allowed to flow out of the furnace every ſix or eight, and in others only every ten or twelve hours. Some workmen imagine, that a conſiderable time is neceſſary for the concoction of the metal. This is certain, that the iron undergoes ſome change by being kept in a fluid ſtate; and that if its fuſion be prolonged much beyond the uſual time, it is rendered leſs fluid, and alſo its coheſion, when it becomes cold, is thereby greatly diminiſhed. The quantity of iron daily obtained from ſuch a furnace as is above deſcribed, is from two to five tons in 24 hours, according to the richneſs and fuſibility of the ore, to the conſtruction of the furnace, to the adjuſtment of the due quantity of flux and of fuel, and to the ſkill employed in conducting the operation.

The quality of the iron is judged by obſerving the appearances during its flowing from the furnace, and when it is fixed and cold. If the fluid iron, while it flows, emits many and large ſparkles; if many brown ſpots appear on it while it is yet red-hot; if, when it is fixed and cold, its corners and edges are thick and rough, and its ſurface is ſpotted; it is known to have a red-ſhort quality. If, in flowing, the iron ſeems covered with a thin glaſſy cruſt, and if, when cold, its texture be whitiſh, it is believed to be cold-ſhort. M. Reaumur ſays, that dark-coloured caſt-iron is more impure than that which is white. The Marquis de Courtivron is of a contrary opinion. But no certain rules for judging of the quality of iron before it be forged can be given. From brittle caſt-iron, ſometimes ductile forged-iron is produced. Caſt-iron with brilliant plates and points, when forged, becomes ſometimes red-ſhort, and ſometimes cold-ſhort. Large ſhining plates, large cavities called eyes, want of ſufficient denſity, are almoſt certain marks of bad iron; but whether it will be cold or red-ſhort cannot be affirmed till it be forged. Whiteneſs of colour, brittleneſs, closeneſs of texture, and hardneſs, are given to almoſt any caſt-iron by ſudden cooling; and we may obſerve, that in general the whiter the metal is, the harder it is alſo, whether theſe properties proceed from the quality of the iron, or from ſudden cooling; and that, therefore, the darker coloured iron is fitter for being caſt into moulds, becauſe it ſeems capable of being filed and poliſhed, eſpecially after it has been expoſed, during ſeveral hours, to a red heat in a reverberatory furnace, and very gradually cooled. This operation, called by the workmen annealing, changes the texture of the metal, renders it ſofter, and more capable of being filed than before, and alſo conſiderably leſs brittle.

It is in fact capable of being ſoftened by annealing, and hardened by ſudden cooling like ſteel, through the heat regained, for theſe changes are greater. Many artiſts avail themſelves of this property to advantage. See Iron.

In Navarre, and in ſome of the ſouthern parts of France, iron ore is ſmelted in furnaces much ſmaller, and of a very different conſtruction from thoſe above deſcribed. A furnace of this kind conſiſts of a wide-mouthed copper caldron, the inner ſurface of which is lined with maſonry a foot thick. The mouth of the caldron is nearly of an oval or elliptic form. The ſpace or cavity contained by the maſonry is the furnace in which the ore is ſmelted. The depth of this cavity is equal to two feet and a half; the larger diameter of the oval mouth of the cavity is about eight feet; and its ſmaller diameter is about ſix feet: the ſpace of the furnace is gradually contracted towards the bottom, the greateſt diameter of which does not exceed ſix feet: eighteen inches above the bottom is a cylindrical channel in one of the longer ſides of the caldron and maſonry, through which the nozzle of the bellows paſſes. This channel, and alſo the bellows-pipe, are ſo inclined, that the wind is directed towards the loweſt point of the oppoſite ſide of the furnace. Another cylindrical channel is in one of the ſhorter ſides of the furnace, at the height of a few inches from the bottom, which is generally kept cloſed, and is opened occaſionally to give paſſage to the ſcoria; and above this is a third channel, in the ſame ſide of the furnace, through which an iron inſtrument is occaſionally introduced to ſtir the fluid metal, and to aſſiſt, as is ſaid, the ſeparation of the ſcoria from it. The greateſt height of this channel is at its external aperture on the outſide of the furnace, and its ſmaller height is at its internal aperture, ſo that the inſtrument may be directed towards the bottom of the furnace; but the ſecond channel below it has a contrary inclination, that when an opening is made, the ſcoria may flow out of the furnace into a baſon placed for its reception. When the furnace is heated ſufficiently, the workmen begin to throw into it alternate charges of charcoal, and of ore previouſly roaſted. They take care to throw the charcoal chiefly on that ſide at which the wind enters, and the ore at the oppoſite ſide. At the end of about four hours a maſs of iron is collected at the bottom of the furnace, which is generally about ſix hundred weight: the bellows are then ſtopt; and when the maſs of iron is become ſolid, the workmen raiſe it from the bottom of the furnace, and place it, while yet ſoft, under a large hammer, where it is forged. The iron produced in theſe furnaces is of the beſt quality; the quantity is alſo very conſiderable, in proportion to the quantity of ore, and to the quantity of fuel employed. In theſe furnaces no lime-ſtone or other ſubſtance is uſed to facilitate the fuſion of the ore. We ſhould receive much inſtruction concerning the ſmelting of iron ore, if we knew upon what part of the proceſs or circumſtance the excellence of the iron obtained in theſe furnaces depends; whether on the quality of the ore; on the diſuſe of any kind of flux, by which the proportion of vitreous or earthy matter, intermixed with the metallic particles, is diminiſhed; on the forging while the iron is yet ſoft and hot, as the Marquis de Courtivron thinks; or on ſome other cauſe not obſerved.

To ſeparate the impurities from caſt-iron, and to unite the metallic parts more cloſely and compactly, and thus to give it the ductility and tenacity which render this metal more uſeful than any other, are the effects produced by the following operations:

The firſt of theſe operations is a fuſion of the iron, by which much of its impurities is ſeparated in form of ſcoria; and by the ſecond operation, a further and more complete ſeparation of theſe impurities, and alſo a cloſer compaction of the metallic particles, are effected by the application of mechanical force or preſſure, by means of large hammers.

Some differences in the conſtruction of the forge or furnace, in which the fuſion or refining of caſt-iron is performed, in the method of conducting the operation, and in ſome other circumſtances, are obſerved to occur in different places. The following, extracted by Keir from Swedenborgius, is the German method.

The fuſion of the caſt-iron, which is to be rendered malleable, is performed upon the hearth of a forge ſimilar to that uſed by blackſmiths: at one ſide of this hearth is formed a cavity or fire-place, which is intended to contain the fuel and the iron to be melted: this fire-place is twenty inches long, eighteen inches broad, and twelve or fourteen inches deep; it is bounded on three ſides by three plates of caſt-iron placed upright, and on the fourth ſide, which is the front, or that part neareſt to which the workmen ſtand, by a large forge hammer, through the eye of which the ſcoria is at certain times allowed to flow. The floor alſo of the fire-place is another caſt-iron plate. The thickneſs of theſe plates is from two to four inches. One of the upright ſide plates reſts againſt a wall, in an aperture through which a copper tube, called the turgere, is luted with clay. This tube is a kind of caſe or covering for the pipe of a pair of bellows placed behind the wall, and its direction is therefore parallel to that of the bellows-pipe; but it advances about half a foot further than this-pipe into the fire-place, and thus gives greater force to the air, which it keeps concentrated, or prevents the divergency of the air, till it is requiſite to act. The tube reſts upon the upper edge of the ſide-plate which leans againſt the wall, nearer to the back part than to the front of the fire-place, and in ſuch an oblique direction, that the wind ſhall be impelled towards the furtheſt part of the floor of the fire-place, or where this floor is interſected by the oppoſite ſide-plate. The obliquity of the turgere ought to vary according to the quality of the iron: and therefore, in every operation it may be ſhifted till its proper poſition is found. The more nearly its direction approaches to a horizontal plane, the more intenſe is the heat; but a larger quantity of fuel is conſumed than is even proportional to the increaſe of heat, becauſe the flame is not then ſo well confined. When the iron is eaſily fuſible, great heat is not required: the turgere may then decline conſiderably from the horizontal plane, and thus fuel may be ſaved. This turgere, though made of copper, a metal more eaſily fuſible than iron, is preſerved from fuſion by the conſtant paſſage of cold air through it. It muſt be carefully kept open, and cleanſed from the ſcoria, which would be apt to block its cavity, by which not only the heat would be too much diminiſhed for the ſucceſs of the operation, but the tube itſelf would be melted.

To prepare for the fuſion, a quantity of ſcoria of a former operation is thrown into the fire-place, till one-third part of this be full; and then the remaining two-thirds of the fire-place are to be filled with ſmaller ſcoria, coal-duſt, and ſparks ejected from hot iron. Theſe matters, being fuſible, form a bath for the reception of the iron when melted. Upon this bed of ſcoria the maſs of caſt-iron to be melted is placed; ſo that one end of it ſhall be within the fire-place, oppoſite to the turgere, and at the diſtance of about four or five inches from its aperture; and the other end ſhall ſtand without the fire-place, to be puſhed in as the former is melted. The upper ſide of the maſs of iron ought to be in the ſame horizontal plane as the upper part of the orifice of the turgere, that the wind may, by means of the obliquity of its courſe, ſtrike upon and paſs along the under-ſide of the maſs: but if the iron be difficultly fuſible, the turgere is to be diſpoſed more horizontally, ſo that the wind ſhall ſtrike directly upon the maſs of iron; and that one part of the blaſt ſhall graze along the upper ſurface, and the other part along the under-ſurface of the iron. The maſs of iron weighs generally from 200 to 400 pounds. Sometimes two or three ſmaller maſſes are put one above another, ſo as not to touch. When theſe are of different qualities, the cold-ſhort piece is placed undermoſt, that being more unfuſible than the red-ſhort. The iron being placed, charcoal powder is thrown on both ſides; and coals are accumulated above, ſo as to cover entirely the iron.

The coals are then to be kindled, and the bellows are made to blow, at firſt ſlowly, and afterwards with gradually increaſed force. The iron is liquefied by degrees, and flows down in drops through the melted ſcoria to the bottom of the fire-place; during which the workmen frequently turn the iron, ſo that the end oppoſed to the blaſt of wind may be equally expoſed to heat, and uniformly fuſed. While the coals are conſumed, more are thrown on, ſo that the whole may be kept quite covered. During the operation, a workman frequently ſounds the bottom and corners of the fire-place, by means of a bar or poker, raiſes up any maſs of metal which he finds adhering to theſe, and expoſes them to the greateſt heat, that they may be more perfectly fuſed.

When all the iron is fuſed, no more coals are to be added, but the melted maſs is to remain half uncovered for ſome time; during which the iron boils and bubbles, and its ſurface ſwells and riſes higher and higher. When the iron has riſen as high as the upper-edge of the fire-place, the coals upon its ſurface muſt be removed; and by thus expoſing it to cold air, its ebullition and ſwelling ſubſide. In this ſtate, or coction, the iron is kept during half an hour, or more, by adding occaſionally pieces of good coal, which maintain a ſufficient heat, without covering entire the ſurface of the maſs. During this coction, the workmen allow the orifice of the turgere to be half ſtopped up by the ſcoria, that the air may not blow upon the iron with all its force, by which it would be too much cooled. Accordingly, when they think that the coction has continued ſufficiently long, they clear the paſſage of the turgere, and the maſs is ſoon cooled by the cold air: at the ſame time alſo, they open a paſſage in the eye of the hammer placed in the front of the fire-place, through which ſome of the ſcoria is allowed to flow out. When the iron has become ſolid, the bellows are ſtopt, the coals are removed, and the maſs is left during an hour; and then the workmen raiſe it from the fire-place, turn it upſide down, and proceed to the ſecond coction or fuſion of the iron.

For this ſecond operation, the maſs is to be ſo placed that one part of it ſhall reſt upon the turgere, and the other upon the ſcoria remaining in the fire-place. This ſcoria is to be diſpoſed in an oblique direction, parallel to the turgere, by which means the wind of the bellows is obliged to paſs all along the under ſide of the maſs of iron. About the ſides of the maſs, charcoal-powder and burnt aſhes are thrown; but towards the turgere, dry and entire pieces of coals are placed to maintain the fire. When theſe are kindled, more coals are added, and the fire is gradually excited. The workman attends to the direction of the flame, that it paſs equally along under the ſurface of the iron, quite to the further extremity, and that it do not eſcape at the ſides, nor be reverberated back towards the turgere, by which this copper tube might be melted. During this fuſion, pieces of iron are apt to be ſeparated from the maſs, and to fall down unfuſed to the bottom and corners of the fire-place. Theſe are carefully to be ſearched for and expoſed to the greateſt heat till they are melted. When the whole maſs is thus brought into perfect fuſion, the coals are removed, and the wind blowing on its ſurface, whirls and diſſipates the ſmall remaining pieces of ſcoria, and ſparks thrown out from the fluid iron. This jet of fire continues about ſeven or eight minutes, and the whole operation about two hours. In this ſecond fuſion the ſcoria is to be thrice removed, by opening a paſſage through the eye of the hammer. The firſt time of removing the ſcoria is about twenty minutes from the kindling of the fire; the ſecond time is about forty minutes after the firſt; and the third time is near the end of the operation.

The maſs is then removed from the hearth, and put upon the ground of the forge, where it is cleanſed from ſcoria, and beat into a more uniform ſhape. It is then placed on an anvil, where, by being forged, it receives a form nearly cubical. This maſs is to be divided into five, ſix, or more pieces, by means of a wedge; and theſe are to be heated and forged till they are reduced to the form of the bars commonly ſold.

In ſome forges the iron is fuſed only once, and in others it ſuffers three fuſions, by which it is ſaid to be rendered very pure. Where only one fuſion is practiſed, it is called the French method. In this no greater quantity of iron is fuſed at once than is ſufficient to make one bar. The fire-place is of conſiderable leſs dimenſions, and eſpecially is leſs deep than in the German method above deſcribed. The fire is alſo more intenſe, and the proportion of fuel conſumed to the iron is greater. The iron, when melted, is not kept in a ſtate of ebullition, as is above deſcribed; but this ebullition is prevented by ſtirring the fluid maſs with an iron bar, till it is coagulated and becomes ſolid.

By theſe operations, fuſion and forging, the iron loſes about $\frac{2}{13}$ parts of its former weight, ſometimes more, and ſometimes leſs, according to the quality of the caſt-iron employed; it is purified from the vitreous and earthy parts which were intermixed with it; its metallic particles are more cloſely compacted, its texture is changed, and it is rendered more denſe, ſoft, and malleable, tough, and difficultly fuſible.

The degrees, however, of theſe qualities vary much in different kinds of iron. Thus ſome iron is tough and malleable, both when it is hot and when it is cold. This is the beſt and moſt uſeful iron. It may be known generally by the equable ſurface of the forged bar, which is free from tranſverſe fiſſures or cracks in the edges; and by a clear, white, ſmall-grained, or rather fibrous texture. Another kind is tough when it is heated, but brittle when it is cold. This is called cold-ſhort iron, and is generally known by a texture conſiſting of large ſhining plates, without any fibres. It is leſs liable to ruſt than other iron. A third kind of iron, called red ſhort, is brittle when hot, and malleable when cold. On the ſurface and edges of the bars of this kind of iron, tranſverſe cracks or fiſſures may be ſeen; and its internal colour is dull and dark. It is very liable to ruſt. Laſtly, ſome iron is brittle, both when hot and when cold.

Many authors aſſert that the red-ſhort quality of iron proceeds from ſome ſulphur or vitriolic acid being contained in it, becauſe ſulphur is known to produce this effect when added to iron, and becauſe the iron obtained from pyritous and other ſulphurated ores has generally this quality. It is with more probability aſſerted by others to ariſe from arſenic; but I know of no direct experiments which aſcertain this fact.

The cauſe of the cold-ſhort quality of iron is well aſcertained to ariſe from the preſence of phoſphorus, or its acid.

In one bar frequently two or more different kinds of iron may be obſerved, which run all along its whole length; and ſcarcely a bar is ever found of entirely pure and homogeneous iron. This difference probably proceeds from the practice we have mentioned of mixing different kinds of ores together in the ſmelting, and alſo from the practice of mixing two or more pigs of caſt-iron of different qualities in the finery of theſe; by which means the red-ſhort and the cold-ſhort qualities of the different kinds are not, as we have already remarked, mutually counteracted or deſtroyed by each other; but each of theſe qualities is diminiſhed in the mixed maſs of iron, as much as this maſs is larger than the part of the maſs originally poſſeſſed of that quality: that is, if equal parts of red-ſhort and of cold-ſhort iron be mixed together, the mixed maſs will be only half as red-ſhort as the former part, and half as cold-ſhort as the latter. For theſe different kinds of iron ſeem as if they were only capable of being interwoven and diffuſed through each other, but not of being intimately united or combined.

The quality of forged iron may be known by the texture which appears on breaking a bar. The beſt and tougheſt iron is that which has the moſt fibrous texture, and is of a clear grayiſh colour. This fibrous appearance is given by the reſiſtance which the particles of the iron make to their rupture. The next beſt iron is that whoſe texture conſiſts of clear whitiſh ſmall grains, intermixed with fibres. Theſe two kinds are malleable, both when hot and when cold, and have great tenacity. Cold-ſhort iron is known by a texture conſiſting of large ſhining plates, without fibres; and red-ſhort iron is diſtinguiſhed by its dark dull colour, and by the tranſverſe cracks and fiſſures on the ſurface and edges of the bars. The quality of iron may be much improved by violent compreſſion, as by forging and rolling, eſpecially when it is not long expoſed to too violent heat, which is known to injure, and at length to deſtroy, its metallic properties.

The following proceſſes are ſufficient to direct the aſſay of iron ores in the furnace.

PROCESS I.

(Extracted from Cramer's Art of Aſſaying, proceſs 54.)

To reduce or precipitate iron out of its ore in a cloſe veſſel.

Roaſt for a few minutes in a teſt under a muffle, and with a pretty ſtrong fire, two centners of the ſmall weight of your iron ore, groſsly pulveriſed, that the volatile matters may be diſſipated in part, and the ore itſelf be ſoftened in caſe it ſhould be too hard. When it is grown cold, beat it extremely fine, and roaſt it a ſecond time, as you do the copper ore, but in a much ſtronger fire, till it no longer emits any ſmell; then let it grow cold again. Compoſe a flux of three parts of the white flux, with one part of fuſible pulveriſed glaſs, or of the like ſterile unſulphureous ſcorias, and add ſandiver and coal-duſt, of each one-half part; add of this flux three times the quantity of your roaſted ore, and mix the whole very well together; then chooſe a very good crucible, well rubbed with lute within, to ſtop the pores which may remain in different places unſeen; put into it the ore mixed with the flux; cover it over with common ſalt, and ſhut it cloſe with a tile, and with lute applied to the points.

Put the wind-furnace upon its bottom part, having a bed made of coal-duſt. Introduce beſides into the furnace, a ſmall grate ſupported on its iron bars, and a ſtone upon it, whereon the crucible may ſtand, as on a ſupport; ſurround the whole with hard coals, not very large, and light them at top: when the veſſel begins to grow red, which is indicated by the common ſalts ceaſing to crackle, ſtop with groſs lute the holes of the bottom part of the furnace, except that in which the nozzle of the bellows is received; blow the fire, and excite it with great force, adding now and then freſh fuel, that the veſſel may never be naked at top: having thus continued your fire in its full ſtrength for three quarters of an hour, or for a whole hour, in the next place take the veſſel out of it, and ſtrike ſeveral times the pavement upon which it is ſet, that the ſmall grains of iron which happen to be diſperſed may be collected into a regulus, which you will find after having broken the veſſel.

When the regulus is weighed, try its malleability; then make it red hot; and when it is ſo, ſtrike it with a hammer: if it bears the ſtrokes of a hammer, both when red-hot and when cold, and extends a little, you may pronounce your iron very good; but if, when either hot or cold, it proves brittle, you may judge it to be not quite pure, but ſtill partly mineralized.

Remarks. The arſenic, but eſpecially the ſulphur, muſt be diſſipated by roaſting; for the former renders the iron brittle, and the latter not only does the ſame, but being managed in a cloſe veſſel, with a ſaline alkaline flux, turns to liver of ſulphur; which acts ſtrongly upon the iron, and prevents its reduction: ſo that the whole, or a great part of it at leaſt, is retained by the ſulphureous ſcoria; in this caſe therefore it is generally in vain to look for a regulus.

The iron obtained from this firſt precipitation has ſcarcely ever the requiſite ductility, but is rather brittle: the reaſon of which is, that ſome of the ſulphur and arſenic remain in it; for, notwithſtanding that the greateſt part of theſe is diſſipated by roaſting, yet ſome part adheres ſo that it can never be ſeparated, but with abſorbent terreſtrial alkaline ingredients, that change the nature of the ſulphur. For which reaſon, in larger operations, they add quicklime, marble, or other lime ſtones; which, while they abſorb theſe minerals, are by it, and by means of the deſtroyed part of their iron, brought to a fuſion, and turn to a vitrified ſcoria, although in other circumſtances they naturally very much reſiſt a vitrification. Another cauſe of the brittleneſs of iron is the unmetallic earth, when it is not yet ſeparated from it; for the iron ore contains a great quantity of it, and in the melting remains joined with the reguline part: whence the iron is rendered very coarſe and brittle. Some iron ores are altogether untractable; and yet the reguli produced out of them, when broken, have ſometimes a neat ſemi-metallic appearance, which undoubtedly proceeds from a mixture of a ſmall quantity of ſome other metal or ſemi-metals.

PROCESS II.

The following proceſs for eſſaying iron ores, and ferruginous ſtones and earths, is extracted from Gellert's Elements of Eſſaying.

Roaſt two quintals of iron ore, or of ferruginous earth: divide the roaſted matter into two equal parts; to each of which add half a quintal of pulveriſed glaſs, if the ſubſtance be fuſible, and contain much metal; but if otherwiſe, add alſo half a quintal of calcined borax. If the roaſting has entirely diſengaged the ſulphur and arſenic, an eighth part, or even half a quintal of quicklime may be added. With the above matters mix 12 pounds of charcoal powder.

Take a good crucible, and cover the bottom and ſides of its inner ſurface with a paſte made of three parts of charcoal duſt, and one part of clay beat together; in the hollow left in this paſte put the above mixture, preſs it lightly down, cover it with pulveriſed glaſs, and put on the lid of the crucible.

Place two ſuch crucibles at the diſtance of about four fingers from the air-pipe, in ſuch a manner that the air ſhall paſs betwixt them at about the third part of the height from the bottom; fill the ſpace between the two crucibles with coals of a moderate ſize; throw lighted coals upon them, that the fire may deſcend, and make them red-hot from top to bottom; at firſt let the bellows blow ſoftly, and afterwards ſtrongly during an hour, or an hour and a quarter; then take away the crucible, and break it when cold. A regulus will be found in the bottom, and ſometimes ſome ſmall grains of iron in the ſcoria, which muſt be ſeparated and weighed along with the regulus; then try the regulus, whether it can be extended under the hammer, when hot and when cold.

Remarks. To diſengage a metal from the earthy matters mixed with it by fire, we muſt change theſe matters into ſcoria or glaſs. This change may be effected by adding ſome ſubſtance capable of diſſolving theſe matters; that is, of converting them into a ſcoria or glaſs, from which the metallic matters may, by their weight, ſeparate and form a regulus at bottom. Fixed alkali, which is an ingredient of the black and of the white flux, is a powerful ſolvent of earths and ſtones: but the alkali (by the aſſiſtance of ſulphur) does alſo diſſolve iron, eſpecially when this metal is in a calcined or earthy ſtate; and the ſolution is ſo much more complete, as the fire is longer applied. Hence, in ordinary eſſays, where an alkaline ſalt is uſed, little or no regulus of iron is obtained. Now, glaſs acts upon, and diſſolves earths and ſtones; but not, or at leaſt in a very ſmall degree, iron; conſequently glaſs is the beſt flux for ſuch eſſays; and experience confirms this aſſertion. If the ore contains but little iron, we may alſo add to the glaſs ſome borax; but borax cannot be employed ſingly, becauſe it very ſoon fuſes and ſeparates from the ore before the metal is revived. Quick-lime is added, not only to abſorb the ſulphur and arſenic remaining in the ore, but alſo becauſe it diſſolves and vitrifies the ſtony and earthy matters of iron ores, which are generally argillaceous. For which reaſon, in the large operations for ſmelting iron ore, quicklime, and even, in certain caſes, gypſum, are commonly added to facilitate the fuſion.

The reduction of iron ore, and even the fuſion of iron, require a violent and long continued heat; and therefore, in this operation, we muſt not employ an inflammable ſubſtance, as pitch, that is ſoon conſumed; but charcoal pulveriſed, which in cloſe veſſels is not ſenſibly waſted. Too much charcoal muſt not be added, elſe it will prevent the action of the glaſs upon the earthy matter of the ore, and conſequently the ſeparation of the metallic part. Experiments convinced Cramer, that one part of charcoal-duſt to eight parts of ore was the beſt proportion.

When iron is ſurrounded by charcoal, it is not decompoſed or deſtroyed: hence the iron of the ore, which ſinks into the hollow made of paſte of charcoal-duſt and clay, remains there unhurt. The clay is added in this paſte to render it more compact, and to keep the fluid iron collected together.

The air is directed between the crucibles, becauſe, if it was thrown directly upon them, they would ſcarcely be able to reſiſt the heat. The ſpace between the air-pipe and the crucibles ought to be conſtantly filled with charcoal, to prevent the cold air from touching the crucibles. Ductile and malleable iron is ſeldom obtained in this firſt operation. The ſulphur and arſenic, and frequently likewiſe an earthy matter adhering to the iron, prevent theſe qualities.

For other particulars reſpecting the properties of iron, and the treatment of its ores, ſee Iron.

ORES OF LEAD. Lead has been found native in various parts of England and elſewhere, or at leaſt in the metallic ſtate. But moſt mineralogiſts queſtion the exiſtence of native lead, and conſider the ſpecimens produced as ſuch, to be either the produce of ancient founderies, or purer kinds of lead ore. Hence we may conclude that the unequivocal ſpecimens of native lead are ſcarce; but the curious ſpecimen mentioned by Bomare, in the ſecond volume of his Mineralogy, quoted by Magellan, appears to be deciſive in favour of the exiſtence of this metal in a native ſtate. It was in the collection of the Abbé Nollin at Paris, and came from the lead mines of Pompean, near Rennes, in Brittany. This metal was very malleable, could be cut with a knife without crumbling, and eaſily melted over the flame of a candle. It weighed about two pounds; was imbedded in an earthy lead ore of a reddiſh colour, and had a ſlaty vein that went through it.

Lead is found mineralized by the vitriolic acid. According to Mr. Monnet, who calls this the pyritous ore of lead, it ſometimes occurs in the form of a white ponderous calx, ſoluble in 16 or 18 times its weight of water. It does not efferveſce, nor is ſoluble in other acids; it may be reduced by laying it on a burning coal. It originates from the ſpontaneous decompoſition of ſulphurated lead ores. Mon. Mineral. 371. According to Dr. Withering, quoted by Kirwan, it is found in great quantity in the iſland of Angleſea, but united to iron, and not reducible by the blow-pipe or charcoal; he promiſes an exact analyſis of it. This is of a yellow colour, and mixed with clay.

The green lead ore, diſcovered by Gahn, conſiſts of lead mineraliſed by the acid of phoſphorus. It may be analyſed in the humid way, by the proceſs mentioned under the article Lead. If urged by the blow-pipe, it melts, and affords an opake globule without reduction, which in cooling aſſumes a polyhedral form, whoſe facets, though apparently plain, are in fact compoſed of concentric ſtriæ, when obſerved by the microſcope.

The red lead ſpar or ore conſiſts of lead mineraliſed by arſenic, and has not hitherto been found elſewhere than at Catherineburgh, in Siberia. Externally it is of a pale, and internally of a deep red colour, and for the moſt part cryſtallized in rhomboidal parallelopipeds, or irregular pyramids. According to Lehman, it contains ſulphur, arſenic, and about 34 per cent. of lead, and alſo ſilver, according to Pallas. Mongez mentions a lead ore of a greeniſh yellow colour, in a matrix of quartz, coming likewiſe, as he was informed, from Siberia, of which he found the mineralizer to be arſenic.

The calciform lead ores contain fixed air, which is conſidered as the mineralizer. They effervefce with acids, and are eaſily reduced on the charcoal. Kirwan diſtinguiſhes five varieties. 1. White lead ſpar, lead ochre, or native ceruſs. It is ſometimes tranſparent, but generally opake, and cryſtallized in regular forms, of a laminar or ſtriated texture. Lead ochre, or native ceruſs, is the ſame ſubſtance, but in a looſe form, or indurated and ſhapeleſs; ſometimes it is found in a ſilky form. Both contain a little iron, and ſometimes calcareous earth and argill. Both grow red hot or yellowiſh when ſufficiently heated. They effervefce with acids, and afford from 60 to 80 or 90 per cent. of lead; both are found in Brittany, Lorain, Germany, and England. 2. Red, brown, or yellow. This is alſo found either regularly cryſtallized, or in ſhapeleſs maſſes, or in powder. It differs from the former only by containing more iron. That in powder contains a mixture of clay. It affords about 70 or 80 per cent. of lead. 3. Green. Either cryſtallized in needles as in Brittany, or in a looſe powder as in Saxony, but moſtly adhering to, or inveſting quartz. It owes its colour to iron, and ſeldom contains copper. 4. Blueiſh. This is alſo ſometimes cryſtallized, ſometimes irregular. 5. Black. The moſt uncommon of all, and occurs either cryſtallized, or of an indeterminate form.

Lead mineralized by ſulphur is the commoneſt of all lead ores. It is known by the name of galena, or potter's lead ore, and is of a blueiſh dark lead colour, formed of cubes of a moderate ſize, or in grains of a cubic figure whoſe corners have been cut off; its texture is lamellar, and its hardneſs variable; the hardeſt ſort containing a greater mixture of iron or quartz; that in grains is thought to be the richeſt in ſilver; but the richeſt contains only about one or 1,5 per cent. that is, 12 or 18 ounces per quintal, the pooreſt about 60 gr. Ores that yield about half an ounce of ſilver per quintal are barely worth the coſt of extracting them: the proportion of ſulphur to lead in this ore is alſo variable within the limits of 15 and 25 per cent. that which contains leaſt is called bley ſchweif, and is in ſome degree malleable. The proportion of lead is from 85 to 60 per cent. by reaſon of an accidental mixture of quartz; that of iron is generally very ſmall. Dr. Watſon remarks, that the ores which are pooreſt in lead are often the richeſt in ſilver. The ſpecific gravity of galena is from 7,000 to 7,780; when melted it yields a yellow ſlag.

The antimonial lead ore has the ſame colour and weight as galena, but its ſtructure is commonly radiated like that of the ore of antimony. Beſides the more accurate methods of humid ſolution, the antimony may be eaſily perceived, though in ſmall quantities, by the white and abundant fumes it emits in roaſting.

In the ſmelting of ores of lead they may be conſidered either as pure, that is, containing no mixture of other metals, or they are mixed with ſilver, copper, or pyrites. The methods of treating ores of lead containing ſilver and copper, are deſcribed in the articles ORES of SILVER and of COPPER, which ſee.

Pure ores of lead, and thoſe which contain ſo ſmall a quantity only of ſilver as not to compenſate for the expence of extracting the nobler metal, may be ſmelted in furnaces, and by operations ſimilar to thoſe uſed at Rammelſberg, or by the following methods:

1. From the lead-ore of Willach in Carinthia, a great part of the lead is obtained by a kind of eliquation, during the roaſting of the ore. For this purpoſe, the ore is thrown upon ſeveral ſtrata or layers of wood, placed in a calcining or reverberatory furnace. By kindling this wood, a great part of the lead flows

out of the ore, through the layers of fuel, into a baſon placed for its reception. The ore which is thus roaſted is beat into ſmaller pieces, and expoſed to a ſecond operation ſimilar to the former, by which more metal is eliquated; and the remaining ore is afterwards ground, waſhed, and ſmelted in the ordinary method.

The lead of Willach is the pureſt of any known. Schlutter aſcribes its great purity to the method uſed in extracting it, by which the moſt fuſible, and conſequently the pureſt part of the contained lead is ſeparated from any leſs fuſible metal which happens to be mixed with it, and which remains in the roaſted ore. This method requires a very large quantity of wood.

2. In England, lead-ores are ſmelted either upon a hearth, or in a reverberatory furnace, called a cupel.

In the firſt of theſe methods, charcoal is employed as fuel, and the fire is excited by bellows. Small quantities of fuel and of ore are thrown alternately and frequently upon the hearth. The fuſion is very ſpeedily effected; and the lead flows from the hearth as faſt as it is ſeparated from the ore.

3. In the ſecond method practiſed in England, pit-coal is uſed as fuel. The ore is melted by means of the flame paſſing over its ſurface; its ſulphur is burnt and diſſipated, while the metal is ſeparated from the ſcoria, and collected at the bottom of the furnace. When the ore is well cleanſed and pure, no addition is requiſite; but when it is mixed with calcareous or earthy matrix, a kind of fluor or fuſible ſpar found in the mines is generally added, to render the ſcoria more fluid, and thereby to aſſiſt the preparation of the metal. When the fuſion has continued about eight hours, a paſſage in the ſide of the furnace is opened, through which the liquid lead flows into an iron ciſtern. But immediately before the lead is allowed to flow out of the furnace, the workmen throw upon the liquid maſs a quantity of ſlaked quick-lime, which renders the ſcoria ſo thick and tenacious, that it may be drawn out of the furnace by rakes. Schlutter mentions this addition of quick-lime in the ſmelting of lead-ores in England, but thinks that it is intended to facilitate the fuſion of the ores; whereas it really has a contrary effect, and is never added till near the end of the operation, when the ſcoria is to be raked from the ſurface of the metal.

ORES OF MANGANESE. From the extreme diſpoſition of manganeſe to become calcined, it is hardly to be expected that a native regulus ſhould be found. But Mr. Peyrouſe deſcribes a ſubſtance of this kind in the Journal de Phyſique for 1786, which appears to be native manganeſe, from the following properties extracted by Magellan[*]. 1. Its external appearance, colour and figure are the very ſame as thoſe of the artificial regulus of manganeſe. 2. It likewiſe ſoils the fingers when handled. 3. Its ſubſtance is quite pure, having no particles that are in the leaſt attracted by the magnet. 4. Its texture is lamellated, and the lamellæ ſeem to affect a kind of divergence among themſelves. 5. It has the very ſame metallic brilliancy as the artificial manganeſium. 6. It has alſo a partial malleability: and, when repeatedly hammered, 7. It exhibits a kind of exfoliation, forming itſelf into very thin leaves. 8. Its opacity and denſity are ſo completely ſimilar to that of the artificial regulus, that, were it not for the natural matrix in which it is imbedded, it could not be at all diſtinguiſhed from it. 9. This ore is not found in large maſſes, or in a ſolid continued body, but only in lumps, and unconnected clots, incloſed and intermixed with the powdery manganeſe ore. 10. Theſe lumps are ſomewhat flattened, or compreſſed in their figure, like the artificial ores, though they are for the moſt part of a larger ſize. 11. And this powdery manganeſian ore, in which the reguline lumps are imbedded, has an argentine hue, which ſeems to countenance the ſuſpicion of its having been acted upon by the violent heat of ſome natural deflagration on the ſpot.

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[*] Cronſtedt, ii. 853.

This new manganeſe ore was found among the iron mines of Sem, on the valley called Viederſos, in the county of Foix, near the Pyrenean mountains.

Fixed air is the only mineralizer of manganeſe in a dry ſtate, yet known. The colours of the compound are different according to the ſtate of calcination of the metallic ſubſtance. For, as Scheele has aſcertained, manganeſe is white when as near the metallic ſtate as poſſible without being actually reduced. This white calx contains about 40 per cent. of fixed air, which prevents its further reduction by expoſure to the atmoſphere. In proportion to its calcination, and by union with other ſubſtances, its colour is either blue, green, yellow, red, brown, or black. It is blue when united with fixed alkalis; yellow always ariſes from the prevalence of the calx of iron; red, from a ſlight calcination of the manganeſe; and black, from its thorough calcination. Yet if the black calx be long roaſted, it becomes green, which Kirwan thinks ariſes from the expulſion of fixed air, which leaves its phlogiſton with the manganeſe, and thus produces a blue, and by mixture with the yellow calx of iron, a green. This author, who has ſince rejected the doctrine of phlogiſton, would probably modify his explanation by ſubſtituting charcoal or the baſis of fixed air inſtead of that principle. The brown colour of manganeſe ariſes from a mixture of the red and black calces. Hence Kirwan diſtinguiſhes three principal varieties of the native calx of manganeſe, the white, the red, and the black, the account of which I ſhall here extract from his Mineralogy.

VARIETY I. White ore of manganeſe. This contains but a very ſmall proportion of iron; it has been found by Mr. Rinman both in ſmall white cryſtals, and in round maſſes, in the cavities of quartz and adhering to glanzblend, rather leſs hard than lime-ſtone, of a ſparry texture, and ſcarcely magnetic, even after roaſting, ſoluble with efferveſcence in nitrous acid, and affording a colourleſs ſolution; which ſolution, with mild alkalis, gave a white precipitate, and the precipitate, when heated, preſently grew black; a ſure criterion of manganeſe.

Mr. Lapeirouſe found this white ore in the form of a ſpungy effloreſcence, vegetating on the ſurface of ſome iron ones, particularily hematites.

It has been ſeen alſo by Mr. Rinman in the form of a calcareous ſpar, of the colour of roſin, and ſomewhat ſhining, in ſome places covered over with a ſooty powder, and in thin pieces ſemi-tranſparent at the edges, and not hard enough to ſtrike fire with ſteel; nitrous acid diſſolves it almoſt entirely; with mild alkalis, the ſolution gives a white precipitate, which blackens when heated. It conſiſts of manganeſe embodied in zeolyte; it melts per ſe with the blow-pipe into a whitiſh gray porous ſlag, and with the addition of calcined borax gives a garnet coloured glaſs.

Many of white ſparry iron ores may alſo be claſſed among the ores of manganeſe, as they contain more of it than of iron.

VARIETY II. Red ore of manganeſe. It contains leſs fixed air, and is accompanied with more iron than the former variety, and alſo with calcareous or ponderous earth and ſilex. It is found either looſe and ſemi-indurated in a matrix of calcareous ſpar, or talky ſchiſtus, or on hematites and other iron ores, or in heavy hard maſſes of a lamellar, radiated, or equable texture, or cryſtallized in pyramids, rhomboids, or ſhort bright brittle needles.

VARIETY III. Black and brown ore of manganeſe. Kirwan places theſe together, as they differ but little; they are found either cryſtallized in the ſame form as the red ore, or in ſolid maſſes, ſome of which have a metallic appearance; others are dull, earthy, and mixed or embodied with quartz, or in a looſe earthy form; their ſpecific gravity is about 4,000. Both, particularly the brown and the red, are ſoluble in ſome meaſure by digeſtion in oil of vitriol, and the ſolution is at firſt reddiſh, but afterwards becomes colourleſs, unleſs they contain a large proportion of iron. But the dephlogiſticated nitrous acid does not act on them except ſugar be added; and then this acid, as well as the concentrated vitriolic, operates a colourleſs ſolution, which with mild alkalis gives a white precipitate of the ſame nature as the firſt variety: they contain more iron and leſs fixed air than the former varieties.

Perigord ſtone belongs to this variety: it is of a dark gray colour, like baſaltes or trapp, may be ſcraped with a knife, yet is difficultly broken; when calcined it becomes of a reddiſh brown colour, and harder, but not magnetic, Its ſpecific gravity is conſiderable; it does not melt per ſe, but with borax it affords an amethyſtine glaſs; nitrous acid ſcarcely acts on it without the addition of ſugar. This ſtone ſeems alſo to contain clay, and ſome portion of iron.

One of the moſt remarkable ores of manganeſe is that called black wad; it is of a dark brown colour, partly in powder, and partly indurated, and brittle. If half a pound of this be dried before a fire, and afterwards ſuffered to cool for about an hour, and then two ounces of lint-ſeed oil be gradually poured on it, mixing them looſely like barm with flour, little clots will be formed, and in ſomething more than half an hour the whole will gradually grow hot, and at laſt burſt into a flame. The temperature of the room where the experiment was made, Mr. Kirwan being preſent, was about 50.: the heat this ore was expoſed to while drying might be about 130.

According to Wedgwood's analyſis, 100 parts of black wad contain 43 of manganeſe, 43 of iron, 4,5 of lead, and five of mica.

To analyſe the above-mentioned ores, they ſhould be firſt roaſted to calcine effectually the manganeſe, and iron if any; then treated with pale nitrous acid to diſſolve the earths; the reſiduum ſhould then be treated with nitrous acid and ſugar, by which means a colourleſs ſolution of manganeſe will be obtained; and this being precipitated by aerated mineral alkali will give a precipitate, 100 gr. of which are equivalent to 100 of regulus of manganeſe.

Many ſpecies of iron ore contain manganeſe. To diſcover it, let the iron be diſſolved in ſome acid, and precipitated by the Pruſſian alkali; let the ſolution be poured off, and the precipitate digeſted in pure water; the Pruſſian manganeſe will be diſſolved, and the Pruſſian iron remain undiſſolved.

Manganeſe ſeems to be contained in the aſhes of moſt vegetables, and to it the blue or greeniſh colour of calcined vegetable alkali is owing. Theſe colours are generally attributed to the phlogiſton of the alkali; but if ſo, they ſhould not be found in fixed nitre, as the nitrous acid ſhould carry off during its decompoſition all the phlogiſton; yet this alkali is always greeniſh, ſo that the colour ſeems to ariſe from the aſhes of the charcoal with which the nitre was decompoſed. If three parts of the alkali of tartar, one of ſifted aſhes, and one-eighth of nitre be melted together, they form a dark green maſs, which being diſſolved in water affords a beautiful green ſolution; and this being filtered, on the addition of a few drops of oil of vitriol, becomes red, and after a few days a brown powder is depoſited, which has the properties of manganeſe. The aſhes of ſerpyllum contain very little of it, thoſe of trees contain moſt. Scheele.

ORES OF MERCURY. Mercury is found in a native ſtate ſufficiently diſtinguiſhable from every other metallic ſubſtance, by its fluidity in every ordinary temperature of the habitable parts of the globe. Bergman doubts whether it be ever found uncontaminated by any other metal. It is found in the quickſilver mines in ſmall brilliant globules, diſſeminated in different gangues. Mongez aſſerts, that it is moſtly in a ſtate of great purity. Sometimes it is collected in the cavities of rocks, as at Idria in Spain, and in America; and in other inſtances it is diſſeminated in the earth, in clays, or adherent to quartzoſe ſtones, pot-ſtone mica, or elſe mixed with different ores, as the white or red ſilver ores, galena, white arſenic, or cinnabar.

Mercury has been found in Sweden and elſewhere, united to ſilver in the form of an amalgam ſometimes cryſtallized.

M. Sage, in the Journal de Phyſique for 1784, mentions a calciform ore of mercury of a red-brown colour, difficult of fracture, preſenting a granulated texture more red than externally. It frequently contains running mercury in its interſtices. By diſtillation the mercury is obtained in the proportion of 91 parts in the centenary. It contains a ſmall part of ſilver, and comes from Idria.

Mercury was found by M. Woulfe at Obermoſchel in the Duchy of Deux-ponts, united with the marine and vitriolic acids. Theſe ores have a ſpar-like appearance, and are either bright and white, or yellow or black mixed with cinnabar in a ſtony matrix. The marine ſalt was in the ſtate of corroſive ſublimate.

The ore of mercury which is wrought in the large way is CINNABAR. It is a combination of mercury with one-fourth of its weight of ſulphur. See the article.

There are other impure cinnabars, particularly one containing copper, which is of a blackiſh gray colour, glaſſy texture, and decrepitates ſtrongly when heated. The cinnabar may be volatilized by heat, and the remaining copper ſhews itſelf by the uſual teſts. The ore of mercury containing iron, and diſtinguiſhed by the name of pyritous mercurial ore, is a gray or whitiſh friable ſubſtance found in Dauphiny, and afforded M. Monnet one part of mercury, leſs than half a part ſilver, and the reſt was iron, cobalt, arſenic, and ſilver.

PROCESS I.

(Cramer, proceſs 8.)

To ſeparate mercury out of an unſulphureous ore by diſtillation.

Take a lump of the pulveriſed ore, one common pound, which muſt ſtand for one centner: put it into a glaſs retort perfectly clean, well loricated, or coated up to half the length of its neck: this muſt be very long, and turned backwards with ſuch a declivity, that a glaſs recipient may be perpendicularly applied to it: but you muſt chooſe a retort ſmall enough, that the belly of it may be filled hardly two thirds with the ore: this retort muſt be placed ſo, that nothing of the fluid adherent to the neck of it may fall into the cavity of the belly, but that the whole may run forward into the recipient. Laſtly, take a ſmall recipient full of cold water: let it be perpendicularly ſituated, and receive the neck of the retort in ſuch a manner that the extremity of it may be hardly one half inch immerſed into the water.

Let the retort be ſurrounded with hot burning coals placed at ſome diſtance in the form of a circle, left the veſſel ſhould burſt by too ſudden a heat: then by degrees bring the burning coals nearer and nearer, and at laſt ſurround the whole retort with them and with freſh charcoal, that it may grow ſlightly red-hot: this fire having been continued for an hour, let the retort cool of itſelf: then ſtrike the neck of it gently, that the large drops which are always adherent to it may fall into the recipient: let the recipient be taken away, and the water ſeparated from the mercury by filtration, and let the mercury be weighed. This operation may be more conveniently performed in a ſand bath; in which caſe the pot containing the ſand muſt be middling red-hot, and the retort be able to touch the bottom of it immediately; nor is it then neceſſary that the retort be loricated.

Process II.

(Cramer, proceſs 59.)

To revive mercury from a ſulphureous cinnabar ore.

Beat your ore extremely fine, and mix it exactly with an equal portion of iron filings, not ruſty; and proceed to diſtil it with the ſame apparatus as in the former proceſs; but urge it with the ſtrongeſt fire that can be made.

Cinnabar may be ſeparated from ſtones by ſublimation as follows: Beat it to a fine powder, and put it into a ſmall, narrow glaſs or earthen cucurbit, the belly of which muſt not fill more than one third part: ſtop the orifice at top; this muſt be very narrow, to hinder the free action of the air. Put this ſmall cucurbit in an earthen pot above two inches wide in diameter, and gather ſand around this pot about as high as the pulverized ore riſes in the cucurbit. Then put it upon burning coals in ſuch a manner that the bottom of the pot may be moderately red-hot. Thus will your cinnabar aſcend, and form a ſolid ponderous ring, which muſt be taken out by breaking the veſſel.

ORES OF MOLYBDENA. See Acid of Molybdena, alſo Molybdena.

ORES OF NICKEL. This ſemi-metal has been found by Rinman in a cobalt mine in Heſſe. The mineral is very ponderous, and of a livid colour. When pulverized and roaſted under a muffle it forms a green excreſcence, and ſmokes; but its ſmoke has no peculiar ſmell, and no ſublimate whether ſulphureous or arſenical can be caught. It affords a green ſolution with acids; but a poliſhed iron plate diſcovers no indication of copper.

Nickel is alſo found in the calciform ſtate, afforded by the decompoſition of kupfer nickel. It uſually has the form of a green effloreſcence, and often covers the ores which contain it. Cronſtedt informs us that it is found at Normark in Warmeland, without any appearance of kupfer nickel, in a clay which contained much native ſilver.

The ore long diſtinguiſhed by the name of kupfer nickel, before the diſcovery of the peculiar metal by Cronſtedt, is of a reddiſh-yellow colour, and of the texture and appearance of a ſlag, or elſe of a fine granular texture, or laſtly, of a ſcaly or lamellar texture. Its brilliancy in ſome meaſure reſembles that of the common pyrites. This ore contains nickel, with iron, cobalt, and arſenic mineralized with ſulphur. See Nickel.

ORES OF PLATINA. This comes to us in an impure native ſtate. Its ores if any are unknown. See Platina.

ORES OF SILVER. The great value of this metal has occaſioned its ores to be very particularly attended to, and enumerated. In the preſent article I ſhall chiefly follow the arrangement of Kirwan.

Native ſilver is found in a granular, lamellar, filamentous, capillary, arboreſcent,

cent, or cryſtallized form, inhering either in baroſelenite, lime-ſtone, ſelenite, quartz, chert, flint, ſerpentine, gneiſs, agate, mica, calcareous ſpar, pyrites, ſchiſtus, clay, &c. alſo in ſeparate maſſes of various ſizes, ſome of the weight of 60 pounds, in or near the veins of moſt metallic ſubſtances, particularly in Peru, and frequently in various parts of Europe, either of a white, brown, or yellowiſh colour.

It is often diffuſed through ſand and ochre, alſo in gray lime-ſtone in Lower Auſtria, and in a greeniſh clay near Schemnitz, or mixed with ochre, clay, and calciform nickel.

It is ſeldom found pure, being generally alloyed with copper, and ſometimes with a ſmall proportion of gold, iron, or regulus of antimony, and ſometimes about five per cent. of arſenic; it is ſeparable from gold and regulus of antimony by ſolution in nitrous acid, and from copper and iron by precipitating it by the marine acid, and from arſenic by torrefaction. Cronſtedt ſays its purity is generally approaching to 16 carats. Lewis aſſerts that it never exceeds this fineneſs. The native ſilver found near Kongſberg contains ſo much gold as to acquire a yellow colour from it.

Horn-ſilver, or corneous ſilver ore, is of a whitiſh-gray or dirty yellow colour, ſometimes ſemi-tranſparent, eaſily cut with a knife, fuſible even by the flame of a candle, and aſſuming a violet colour by the ſun's rays. One hundred grains contain 75 of real ſilver. It is reducible by triturating it with about its own weight of fixed alkali with a little water, then melting the whole in a crucible, whoſe bottom is covered with mineral alkali well preſſed, and covering the maſs of horn-ſilver alſo with the mineral alkali.

The vitreous ſilver ore (glaſzertz) is mineralized by ſulphur. It is found either in ſolid large lumps, or inhering in quartz, ſpar, gypſum, gneiſs, pyrites, &c. of a lamellar, granular or capillary form cryſtallized: it is generally of a lead colour firſt, but grows black by expoſure to the air, but ſometimes gray or black, even when firſt broken; its laminæ are flexible and ductile, and even malleable in ſome degree, and ſo ſoft, that they may be cut with a knife; its ſpecific gravity is 7.200*; it is one of the richeſt of the ſilver ores.

One hundred parts of it contain from 72 to 77 of ſilver; it is rarely contaminated with any other metal beſides a ſmall proportion of iron.

It is found in Hungary near Schemnitz, and in Saxony near Freyburgh, particularly in the famous mine of Himmelsfurſt.

It is analyſed by boiling in moderately dilute nitrous acid, uſing about 25 times its weight, till the ſulphur is quite exhauſted. The ſilver is precipitated by marine acid, or common ſalt. The Pruſſian alkali will ſhew if any other metal is contained in the ſolution: the gold, if any, will remain undiſſolved; fixed alkalis will precipitate any other earthy matters contained in the ſolution.

In the dry way it may be reduced by melting it with the blow-pipe on charcoal; for the ſulphur is diſſipated, and the ſilver remains; or by melting it with $\frac{1}{8}$ of its weight of filings of iron, as the iron will take up the ſulphur, and be ſcorified.

Silver is either mineralized by a ſmall or a large proportion of arſenic. The ore which is mineralized by a ſmall proportion of arſenic, is of a yellowiſh-white colour, and of a ſtriated texture, reſembling biſmuth, but much harder; it melts very eaſily; and if kept in fuſion, it loſes its arſenic, and the ſilver remains almoſt entirely pure, as it contains but very little iron; it contains about 90 per cent. of ſilver, and is found near Quadanal Canal in Spain.

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* Gellert Anfangs, 234.

The proportion of arſenic in that ſilver ore which is mineralized by a large proportion of it, is ſo great, that it would ſcarce deſerve to be called a ſilver ore, if the arſenic were not eaſily diſſipated: the quintal contains but from four to ſix ounces of ſilver: it is very ſoft, and eaſily cut, and when cut has a brilliant metallic appearance; it conſiſts of conchoidal laminæ; it is alſo found at Quadanal Canal.

It is reduced by evaporating the arſenic, which then leaves the ſilver ſlightly contaminated with iron.

The red ſilver ore is mineralized by ſulphur and arſenic (rothgulden ertz). This is a heavy, ſhining ſubſtance, either tranſparent or opake, moſtly of a crimſon or reddiſh colour, though ſometimes gray or blackiſh, but when ſcraped or powdered always reddiſh; found either in irregular maſſes, or cryſtallized in pyramids or polygons, or dendritical, or plated or radiated incruſtations, on or in matrixes of quartz, flint, ſpar, pyrites, ſparry iron ore, lead ore, pyrites, cobalt ore, jaſper, baroſelenite, gneiſs, &c. When radiated or ſtriated, it is called rothgulden bluth. In the fire it crackles and melts after it has acquired a red heat, with an arſenical ſmell; it detonates with nitre: its ſpecific gravity is from 5.4 to 5.684. Bergman found 100 grains of it to contain 60 of ſilver, 27 of arſenic, and 13 of ſulphur; but ſometimes it contains even 70 per cent. of ſilver. The darkeſt ores are the richeſt, and theſe often contain a little iron; the yelloweſt are the pooreſt; the moſt yellow does not belong to this ſpecies, being in fact orpiment, containing ſix or ſeven per cent. of ſilver.

To analyſe this ore in the moiſt way, Bergman adviſes to boil it after it is reduced to a very fine powder in dilute nitrous acids, and to edulcorate the reſiduum very carefully which contains the ſulphur and arſenic, which may be ſeparated by boiling in a ſufficient quantity of aqua regia: if the ſulphur ſtill retains any luna cornea, it may be ſeparated by cauſtic volatile alkali.

In the dry way it is reduced after torrefaction by a mixture of iron and lead; the iron takes up the ſulphur, and the lead the ſilver, which is afterwards ſeparated by cupellation.

Silver mineralized by ſulphur, and a very ſmall portion of arſenic and iron, is called black ſilver ore, ſchwartz ertz, ſchwartz gulden, ſilber mulm. This is either of a ſolid and brittle conſiſtence, which diſtinguiſhes it from the vitreous ore, and of a glaſſy appearance in its fracture when recent, or of a looſer texture, and ſooty or deep black colour, like moſs or thin leaves lying on the ſurface of other ſilver ores, or of thoſe of lead or cobalt, or in clays, ponderous ſpar, gneiſs, &c. It may contain about 25 per cent. of ſilver: the former is found in Dauphiné, Hungary, and Saxony, and contains at moſt 60 per cent. of ſilver.

Another ſpecies of ſilver ore mineralized by arſenic, and containing a large proportion of iron, is called arſenico-martial ſilver ore, weiſs ertz, pyrites argenteus of Henckel.

Mineralogiſts do not well agree about the ore to which this denomination belongs. Kirwan follows Monnet, who ſeems to have attended moſt exactly to the diviſion of ores. According to him, this ore is a hard ſubſtance, of a white, ſhining appearance, and of a compact, lamellar or fibrous texture; the brighteſt is the pooreſt in ſilver; the richeſt gives only 10 per cent. the pooreſt ſix or eight ounces: it contains no ſulphur; and hence Monnet calls it a metallic regulus, not conſidering that the iron is in a calcined ſtate: the iron and arſenic are in various proportions, but the arſenic always exceeds.

It is found in Saxony, the Hartz, at Quadanal Canal, &c. and is eſſayed in the moiſt way.

White ſilver ore (weis gulden) is mineralized by arſenic and ſulphur, with a ſmall proportion of copper, and a ſtill ſmaller of iron. It is a heavy, ſoft, opake ſubſtance, fine grained or ſcaly, bright and ſhining in its fractures, of a whitiſh, ſteely or lead colour, ſometimes cryſtallized in pyramidical or cylindrical forms, but often in irregular grains, or reſembling moſs, or in the form of thin laminæ incruſtating other bodies, found in quartz, ſpar, ſtelleſtein, pyrites, blend, lead ore, cobalt ore, ſparry iron ore, fluors, &c. It is very fuſible; its ſpecific gravity 5,000 to 5,300; its proportion of ſilver from 10 to 30 per cent.

It is found, though not commonly, in Saxony, Hungary, the Hartz, and St. Marie aux Mines.

Bergman analyſes this ore in the following manner: Having pulverized and weighed a certain portion of it, he attempts its ſolution in about 12 times its weight of dilute nitrous acid: the copper and ſilver are diſſolved, and a white reſiduum remains. The ſilver he precipitates, not with marine acid, for this would unite alſo to the copper, and with the ſilver form a triple ſalt, which would alſo fall, but with a clean plate of copper previouſly weighed; the ſilver being in its metallic form, may immediately be weighed, and its contents known: the copper ſhould then be precipitated by aerated mineral alkali; 194 grains of this precipitate well dried are equivalent to 100 of copper in its metallic form; but from this laſt, the weight, which the plate of copper loſt, muſt be ſubtracted.

The white reſiduum, containing the ſulphur, arſenic and iron, is next to be examined: by boiling it in ſpirit of ſalt, the arſenic and iron are taken up; the arſenic is to be precipitated by the addition of water, and then the iron by the Pruſſian alkali; the ſulphur remains undiſſolved, and may be treated with volatile alkali to try whether it retains any copper or horn ſilver.

Gray ſilver ore (fahlerz) is mineralized by arſenic and ſulphur, with a large proportion of copper and ſome iron. This is a hard, gray, or dark gray ſubſtance, more or leſs brilliant, ſometimes cryſtallized, but moſtly irregular, and is, in fact, the gray copper ore impregnated with ſilver, and varies much in its contents from about one to 12 per cent. of ſilver, and from 12 to 24 of copper, the remainder being ſulphur and arſenic, with a little iron: the richer it is in copper, the poorer in ſilver, and reciprocally. Monnet remarks, that wherever copper is united to arſenic, ſilver is alſo found; it is the commoneſt of all the ſilver ores: the gray ſilver ore of Dal in Sweden contains alſo regulus of antimony, and according to Bergman, it contains 24 per cent. of copper, and five of ſilver; but this belongs to the next ſpecies, which is

Brown ſilver ore (leber erz), and is mineralized by arſenic and ſulphur, with copper, iron, and regulus of antimony. The colour of this ore is moſtly of a reddiſh brown, ſometimes dark gray; ſometimes it is found cryſtallized in pyramids, but moſtly irregular; when ſcraped it appears red; it contains from one to five per cent. of ſilver; the greateſt part is copper, and the next in proportion is arſenic.

It is found in Sweden, Germany, and Spain.

It is analyſed by boiling it in about ſix times its weight of dilute nitrous acid, which will take up the ſilver and copper, and leave the regulus of antimony and arſenic: theſe being boiled in ſtrong nitrous acid are dephlogiſticated, and the arſenic becomes ſoluble in water; the calx of antimony remains undiſſolved; the ſulphur may be found in a ſecond experiment, uſing aqua regia inſtead of the concentrated nitrous acid; the ſilver and copper are ſeparated, as in the proceſs for the white ſilver ore.

Plumoſe ſilver ore (feder ertz) is mineralized by ſulphur and arſenic, with iron and regulus of antimony. In point of colour this ore varies from a dull white to gray, dark blue, brown or black; it is found in a capillary form, or like wool, ſometimes looſe, at other times attached; its filaments are rigid and inflexible; the whiter it is, the richer; but it ſeldom contains even one per cent. of ſilver. It is found in Saxony and elſewhere. Some confound it with the foregoing.

Its analyſis may be underſtood from the proceſſes with the white and brown ſilver ores.

Cobaltic ſilver ore is mineralized by ſulphur and arſenic, with cobalt and iron. This ore is diſtinguiſhed by roſe-coloured particles of cobalt diſperſed through a dark brown, blackiſh, or gray, and ſomewhat ſhining ſolid maſs. It is found in Saxony, and at Allemont in Dauphiné, and contains about 40 or 50 per cent. of ſilver, and very little cobalt; the arſenic is in an acid ſtate, and united to the cobalt.

To analyſe it, let it be diſſolved in nitrous acid; the ſilver and cobalt will be taken up, and moſt of the iron will remain calcined, together with the arſenic; the ſilver may be precipitated by the marine acid, and the cobalt by mild mineral alkali: 160 grs. of the precipitate denote 100 of cobalt in its metallic ſtate.

Butter-milk ore is mineralized by ſulphur, with regulus of antimony and barytes; and appears in the form of thin pellicles on granular ſpar.

The combuſtible ſilver ore is black and brittle, leaves about ſix per cent. of ſilver in its aſhes, and is a coal in which ſilver is found. The ſilver is extracted as uſual by nitrous acid.

Corneous ſilver ore (horn ertz) is mineralized by the vitriolic and marine acids, with a little iron, and ſometimes with a mixture of the vitreous ore. This ſcarce and valuable ore is of a white, gray, pearly, or yellow, green, brown, purple, or black colour, frequently cryſtallized in a cubic form, ſometimes reſembling an earth, eaſily fuſible without any ſmoke. The black ſort is friable, and eaſily pulveriſed; but the other ſort is in ſome degree malleable, may be cut with a knife, and takes a ſort of poliſh when rubbed. The vitreous ore mixed with the black is ſoluble in nitrous acid, and may by that means be ſeparated, the ſaline ores being inſoluble in that acid; if pure from iron, theſe ores ſhould contain 70 per cent. of ſilver at leaſt, but they moſtly contain ſome portion of iron, of which ſome is even united to the marine acid, according to Monnet. It is found in Saxony, Bohemia, St. Marie aux Mines, Siberia, and Peru. It was firſt aſſayed by Wolfe, Phil. Tranſ. 1776, and afterwards, though leſs exactly, by Monnet, in 1777.

Bergman gives the following moſt ingenious method of analyſing theſe ores in the moiſt way.

1°. He digeſts this compound ore in the marine acid for 24 hours, by which means the vitriol of ſilver is decompoſed, and the whole is converted into horn ſilver. He then judges of the quantity of the vitriol of ſilver, by the quantity of vitriolic acid let looſe in the liquor; and to find how much this is, he decants the clear liquor, and drops into it a ſolution of nitrous baroſelenite, which is immediately decompoſed by the vitriolic acid, and forms true vitriolic baroſelenite, of which 100 grains contain 15 of dephlegmated vitriolic acid, and ſo in proportion. Now 100 grains of vitriol of ſilver contain 25.37 of the ſame dephlegmated acid, ſo that 25,37 grains of this acid indicate 100 of vitriol of ſilver, and ſo in proportion; and thus the quantity of ſilver in the vitriol of ſilver is alſo found, as 100 grains of it contain 74,62 of ſilver*, and the proportion of vitriol of ſilver being known, that of horn ſilver of courſe is known; but if the ore be of the black kind, after the whole is turned into horn ſilver, it ſhould be digeſted in cauſtic volatile alkali, which will take up the horn ſilver, and leave the vitreous ore. The iron, if any, ſhould be precipitated from the firſt ſolution, by the Pruſſian alkali, after the precipitation of the baroſelenite.

The following proceſſes, like the others extracted from Cramer's Art of Aſſaying, are valuable for the minute accuracy of the inſtruction as to management of aſſays by the furnace.

PROCESS I.

To precipitate ſilver by means of lead from fuſible ores.

Pound the ore in a very clean iron mortar into fine powder: of this weigh one docimaſtical centner or quintal, and eight of the like centners of granulated lead.

Then have at hand the docimaſtical teſt, which muſt not as yet have ſerved to any operation: pour into it about half of the granulated lead, and ſpread it with your finger through the cavity of it.

Put upon this lead the pounded ore; and then cover it quite with the remainder of the granulated lead.

Put the teſt, thus loaded, under the muffle of an eſſay-furnace, and in the hinder part of it: then make your fire, and increaſe it gradually. If you look through the holes of either of the ſlides, you will ſoon ſee that the pounded ore will be raiſed out of the melted lead, and ſwim upon it. A little afterwards, it will grow clammy, melt, and be thrown towards the border of the teſt: then the ſurface of the lead will appear in the middle of the teſt like a bright diſk, and you will ſee it ſmoke and boil: as ſoon as you ſee this, it will be proper to diminiſh the fire a ſmall matter for a quarter of an hour, ſo that the boiling of the lead may almoſt ceaſe. Then again increaſe the fire to ſuch a degree that the whole maſs may be converted into a thin fluid, and the lead may be ſeen, as before, ſmoking and boiling with great violence. The ſurface will then diminiſh by degrees, and become covered with a maſs of ſcorias. Finally, have at hand an iron hook ready heated, wherewith the whole maſs muſt be ſtirred, eſpecially towards the border; that in caſe any ſmall parcels of the ore, not yet diſſolved, ſhould be adherent there, they may be brought down, taking great care not to ſtir the leaſt particle out of the teſt.

Now, if what is adherent to the hook during the ſtirring, when you raiſe it above the teſt, melts quickly again, and the extremity of the hook, grown cold, is covered with a thin, ſmooth, ſhining cruſt; it is a ſign that the ſcorification is perfect; and it will be the more ſo, as the ſaid cruſt adherent to the hook ſhall be coloured equally on every ſide; but in caſe, while the ſcorias are ſtirred, you perceive any conſiderable clammineſs in them, and when they adhere in good quantity

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* According to Bergman, 100 parts of vitriol of ſilver contain but 68,75 of ſilver.

tity to the hook, though red-hot, and are unequally tinged, and ſeem duſty or rough with grains interſperſed here and there; it is a ſign that the ore is not entirely vitrified. In this caſe, you muſt with a hammer ſtrike off what is adherent to the hook, pulverize it, and with a ladle put it again into the teſt, without any loſs or mixture of any foreign body, and continue the fire in the ſame degree till the ſcoria has acquired its perfection, and the above-mentioned qualities. This once obtained, take the teſt with a pair of tongs out of the fire, and pour the lead, together with the ſcoria ſwimming upon it, into a cone made hot and rubbed with tallow. Thus will the proceſs of the firſt operation be performed, which does not commonly, indeed, laſt above three quarters of an hour.

With a hammer ſtrike the ſcorias off from the regulus grown cold, and again examine whether they have the characteriſtics of a perfect ſcorification: if they have, you may thence conclude, that the ſilver has been precipitated out of the ore turned to ſcorias, and received by the lead.

When the ſcorification laſts longer than we mentioned, the lead at laſt turns to ſcorias or litharge, and the ſilver remains at the bottom of the veſſel; but the fire muſt be moderately ſupplied, and the veſſel be extremely good, to produce this effect; for they ſeldom reſiſt the ſtrength of the ſcorias long enough; ſo that the whole ſcorification may be brought to an end; which has afterwards this inconveniency, that the ſilver is diſſipated by grains in the ſmall hollows of the corroded ore, and can hardly be well collected again, when the ore has but little ſilver in it. Indeed, there is ſtill more time to be conſumed to obtain the perfect deſtruction of the lead, by means of the combined actions of the fire and air, becauſe the ſcorias ſwimming at the top retard it conſiderably.

In this proceſs, the ſulphur and the arſenic of the ſilver ore, when the ore is broken ſmall, and extended widely in a ſmall quantity, are in part eaſily diſſipated by the fire, and in part abſorbed by the lead; the lighter part of which, ſwimming upon the heavier, becomes very clammy by means of the ſulphur which is in the ore; but when this is diſſipated by the violence of fire, it turns into glaſs or ſcorias: but when arſenic is predominant in the ore, the plumbeous part turns immediately into a very penetrating and very fuſible glaſs, having a diſſolving efficacy, unleſs the arſenic lies hidden in a white pyrite or cobalt. For this reaſon, the fixed part of the ore, which is no ſilver, is diſſolved by that glaſs, melts, and aſſumes the form of ſcorias. The unmetallic earths and the pure copper of lead-ores which adhere to it are of this kind. The ſilver then remains immutable; and being freed from theſe heterogeneous bodies, which are partly diſſipated and partly melted, it is precipitated and received by the remaining regulus of lead. Hence this proceſs is completed by three diſtinct operations; viz. 1. By roaſting. 2. By ſcorification. 3. By the melting precipitation of the ſilver, which is the reſult of the two former operations.

The ore muſt be pulverized very fine in order to increaſe the ſurface, that the diſſipation of the volatiles, and the diſſolution by litharge, may be ſooner effected. This pulveriſing muſt then be done before the ore is weighed, becauſe there is always ſome part of the ore adherent to the mortar or iron plate on which it is made fine; which part being loſt, the operation is not exact. Erker was in the right when he preſcribed eight centners of lead for the ſubduing of fuſible ores. Nevertheleſs, it muſt be owned that this quantity is ſuperfluous in ſome caſes. However, as the fluxibility of the ſilver ore depends on the abſence of ſtones, pyrites, &c. it is eaſy to ſee that there are an infinite number of degrees of fluxibility which it would be needleſs to determine by the bare ſight. Beſides, a little more lead does not render the proceſs imperfect; on the contrary, if you uſe too ſmall a quantity of lead, the ſcorification is never completely made. Indeed, there are a great many ores containing ſulphur and arſenic in abundance, that deſtroy a conſiderable quantity of lead: ſuch are the red ſilver ore, and that in which there is a great deal of the ſteel-grained lead ore. If the fire muſt be ſometimes diminiſhed in the middle of the proceſs, it is in order to hinder the too much attenuated litharge, which is continually generated out of the lead, from penetrating the pores of the teſt, and from corroding it; which is eaſily done when the fire is over ſtrong; for then the ſurface of the veſſel which is contiguous to the lead contracts cavities, or, being totally conſumed by ſmall holes, lets the regulus flow out of it. The veſſels that are moſt ſubject to this inconvenience are thoſe, in the materials of which lime, plaſter, and chalk, are mixed. Nay, theſe bodies, which are naturally refractory, being eroded during their ſcorification, at the ſame time communicate a great clamminеſs to the ſcoria; ſo that a great quantity of the maſs remains adherent to the teſt in the form of protuberances, when it is poured out; and by this means a great many grains of the regulus are detained.

PROCESS II.

The regulus obtained by the preceding proceſs, contains all the ſilver of the ore, and the unſcorified part of the lead. The ſilver may be afterwards ſeparated from the lead, and obtained pure by cupellation.

PROCESS III.

(Art of Aſſaying, Part II. proceſs 3.)

If the ſilver ore cannot be waſhed clean, or if it be rendered refractory by a mixture of unmetallic earths and ſtones, the ſcorification of theſe earthy matters frequently cannot be completed by Proceſs I. Cramer *therefore directs that ſuch ores ſhall be treated in the following manner.*

Bruiſe the ore into an impalpable powder, by grinding in a mortar; to a docimaſtical centner of it add a like quantity of glaſs of lead, finely pulveriſed; for the more exactly theſe two are mixed together, the more eaſily the ſcorification afterwards ſucceeds. Put this mixture, together with twelve centners of lead, into the teſt, according to Proceſs I.; then put the teſt under the muffle.

Make firſt under it a ſtrong fire, till the lead boils very well; when this takes place, diminiſh the violence of the heat, as was directed in Proceſs I. But keep it thus diminiſhed a little longer: then finally again increaſe the fire to ſuch a degree, till you perceive the ſigns of a perfect ſcorification and fuſion. Now this proceſs laſts a little longer than the foregoing, and requires a greater fire towards the end.

It ſometimes happens that a very refractory ore cannot be diſſolved by litharge, and that a maſs, which has the clammineſs of pitch, ſwims upon the regulus and upon the ſcorias themſelves, which are already ſubdued in part: when this takes place, ſhut the vents of the furnace to diminiſh the fire; then gently touch this refractory body with a ſmall cold iron hook, to which it will immediately ſtick; take it off ſoftly, not to loſe any thing; pound it into a fine powder, adding a little glaſs of lead, and put it again into the teſt; then continue the ſcorification, till it is brought to its perfection. But you muſt always examine the ſcoria of your refractory ore, to ſee whether there may not be ſome grains of regulus diſperſed in it; for ſometimes the ſcorias that grow clammy retain ſomething of the metal; which if you ſuſpect, pound the ſcoria into a fine duſt, and thus the grains of metal will appear, if there are any left, becauſe they can never be pounded fine. The ſilver is ſeparated from the regulus by copelling, as in Proceſs I.

All earths and ſtones are refractory in the fire; for, although ſome of them melt naturally in the fire, as is the caſe with thoſe that are vitrifiable; yet all the others, a very few excepted, melt with much greater difficulty than metals, and never become ſo thin in the fuſion as is requiſite for the ſufficient precipitation of a precious metal. But litharge itſelf does not conveniently diſſolve theſe refractory matters by the help of fire alone, unleſs ſome mechanical mixture is added to them; for the very moment the ſaid litharge penetrates through the interſtices of the refractory ore, and begins to diſſolve it, a tenacious maſs is produced, which hardly admits any farther dilution by the litharge. You may plainly perceive it, if you make coloured glaſſes with metallic calces; if you pour careleſsly upon them a calx that gives a colour, you will never cauſe them to be equally dyed on every ſide, even though you ſhould torture them for whole days together in a ſtrong fire. Indeed, glaſs already made can never be diluted by only pouring ſalts and litharge upon it. Hence, you muſt uſe the artifice of glaſs-makers, who, in the making of the moſt perfect glaſſes, take great care, before they put the ſpecies of their ingredients into the fire, to have a mechanical mixture precede, or at leaſt accede, during the fuſion itſelf, which is done here by pounding glaſs of lead mixed with the ore: but if you think that your glaſs of lead is not ſufficiently fuſible, you may add to it litharge, melted firſt, and then pounded into a fine powder.

As this ſcorification requires a longer and a greater fire than the foregoing, and as a greater quantity of litharge is beſides this requiſite to ſubdue the refractory ſcoria; it is eaſy to ſee why a much greater quantity of lead muſt be uſed here than in Proceſs I.; and although leſs lead is often ſufficient, it is nevertheleſs proper always to uſe the greateſt quantity that can be neceſſary; leſt, for inſtance, it ſhould be neceſſary to try ſo many times the lead alone, to make it evident how much ſilver the lead, when alone, leaves in the coppel. Nor is there any occaſion to fear leſt any thing of the ſilver be taken away by the lead, provided the coppels be good, and the coppelling duly put in execution: for you can hardly collect a ponderable quantity of ſilver out of the collected fume of the lead, which riſes during the coppelling, as well as out of the litharge, that is withdrawn into the coppel.

Process IV.

(Art of Aſſaying, Part II. proceſs 4.)

If the ore be rendered refractory by pyrites, Cramer *directs that the ſilver ſhould be precipitated by lead in the following manner.*

Break your ore into a rough powder, and put a centner of it into the teſt: put upon this another teſt in the manner of a tile; put it under the muffle hardly red-hot: increaſe the fire by degrees. There will always be a crackling; which being ended, take away the upper teſt; for when the veſſels have been red-hot about one minute, the ore ceaſes to ſplit. Leave the ore under the muffle till the arſenic and the ſulphur are for the moſt part evaporated; which you will know from the ceſſation of the viſible ſmoke, of the ſmell of garlic, or the acid; then take away the teſt, and leave it in a place not too cold, that it may cool of itſelf.

Pour out, without any diſſipation, the roaſted ore, and with a knife take away what is adherent to the veſſel; pound it to a moſt ſubtle powder, and grind it together with an equal weight of glaſs of lead; and laſtly, ſcorify the whole collected ore in the ſame teſt in which the teſting was made, unleſs it has contracted chinks, as was deſcribed in Proceſs III.

Remarks. Yellow pyrites-ores contain a very great quantity of ſulphur, even greater than is neceſſary to ſaturate the metal that lies concealed in them. For which reaſon this ſuperfluous ſulphur diſſipates in a middling fire; but if it had been mixed with lead it would have rendered it refractory, nor could it afterwards be diſſipated from it without a conſiderable deſtruction of the lead. The white arſenical pyrites turn alſo a great quantity of lead into glaſs, on account of the abundance of the arſenic they contain. In conſequence of this, theſe ores muſt be previouſly roaſted, that the ſulphur and arſenic may be diſſipated. Nor is there any occaſion to fear leſt any part of the ſilver be carried away with the arſenic; for when arſenic is ſeparated from any fixed body, by a certain degree of fire, it carries nothing of that body away with it.

PROCESS V.

(Art of Aſſaying, Part II. proceſs 9.)

Silver may be precipitated from its ore by cupellation only, in the following proceſs, given by Cramer.

Pound one centner of ore, roaſted in the manner directed in the laſt proceſs; beat it to a moſt ſubtle powder; and if it melts with difficulty on the fire, grind it together with one centner of litharge, which is not neceſſary when the ore melts eaſily; then divide the mixture, or the powder of the ore alone, into five or ſix parts, and wrap up every one of them ſeverally in ſuch bits of paper as can contain no more than this ſmall portion.

Put a very large coppel under the muffle; roaſt it well firſt, and then put into it 16 centners of lead: when the lead begins to ſmoke and boil, put upon it one of theſe portions with the ſmall paper it was wrapt up in, and diminiſh the fire immediately, in the ſame manner as if you would make a ſcorification in a teſt, but in a leſſer time. The ſmall paper, which turns preſently to aſhes, goes off of itſelf, and does not ſenſibly increaſe the maſs of the ſcorias. The ore proceeding from this is caſt on the border, and very ſoon turns to ſcorias. Increaſe the fire again immediately, and at the ſame time put another portion of the ore into the coppel. The ſame effects will then be produced. Continue your operations in the ſame manner, till all the portions are thrown in and conſumed in the lead. Laſtly, deſtroy the remaining lead with a ſtronger fire.

The ſilver that was in the ore and in the lead will remain in the coppel. If you deduct from it the bead proceeding from the lead, you will have the weight of the ſilver contained in the ore. If the ore employed was eaſy to be melted, all the ſcoria vaniſhes; but if it was refractory or not fuſible, all the ſcoria does not always paſs away, but there remains ſomething of it occaſionally in the form of duſt. A great many ores and metals may be tried this way, except ſuch only as ſplit and corrode the coppels. There are likewiſe ſome of them which muſt be previouſly prepared, in the ſame manner as is required to render them fit for going through a ſcorification. See the preceding PROCESSES.

Remarks. The ore thrown at ſeveral times upon lead boiling in a coppel, may be diſſolved without the foregoing ſcorification: but this is very far from having an equal ſucceſs with all kinds of ores; for there are ores and metals which reſiſt very much their diſſolution by litharge; and which being on this account thrown on the border, are not ſufficiently diſſolved; becauſe the litharge ſoon ſteals away into the coppel. Nevertheleſs there are ſome others which vaniſh entirely by this method, except the ſilver and gold that were contained in them. —A previous roaſting is neceſſary; firſt, for the reaſons mentioned, and then becauſe the ore thrown upon boiling lead ſhould not crackle and leap out; for, having once paſſed the fire, it bears the moſt ſudden heat.

PROCESS VI.

(Cramer, proceſs 15.)

Silver may be precipitated out of the ſame bodies as were mentioned in the foregoing proceſſes, by ſcorification in a crucible.

The body out of which you intend to precipitate ſilver muſt be previouſly prepared for a ſcorification by pounding and roaſting, as mentioned in the former proceſſes. Then in the ſame manner, and with the ſame quantity of lead, put it into a crucible ſtrictly examined, that it be entire, ſolid, not ſpeckled with black ſpots, like the ſcoria of iron, eſpecially at its inferior parts, and capable of containing three times as much. Add beſides glaſs-gall and common ſalt, both very dry, and in ſufficient quantities, that, when the whole is melted, the ſalts may ſwim at top at the height of about half an inch.

Put the crucible thus loaded into a wind-furnace; ſhut it cloſe with a tile; put coals round it, but not higher than the upper border of the crucible. Then light them with burning coals, and increaſe the fire till the whole melts very thin, which will be done by a middling fire, maintained always equal, and never greater: leave it thus for about one quarter of an hour, that the ſcorification may be perfectly made. Take off the tile, and ſtir the maſs with an iron wire, and a little after pour it out into the mould. When the regulus is cleared from ſcorias, try it in a teſt by coppelling it.

Remarks. The ſcorification of any ore whatever, or of any body fetched out of ores, may indeed be made by this apparatus, as well as in a teſt under a muffle: but it ſerves chiefly to the end that a greater quantity of metal may be melted from it with profit. For you may put many common pounds of it at one ſingle time into the crucible; but then you need not obſerve the proportion of lead preſcribed in the foregoing proceſs; indeed, a quantity of lead two or three times leſs is ſufficient, according to the different qualities of the object. But the maſs will certainly be ſpilt, unleſs you chooſe a very good crucible; for there is no veſſel charged with litharge, that can bear a ſtrong fire having a draught of wind, without giving way through it to the litharge.

You add glaſs-gall and common ſalt, that they may forward the ſcorification, by ſwimming at top; for the refractory ſcoria rejected by the litharge, and adhering between this and the ſalts that ſwim at top, is ſoon brought to a flux, and the precipitation of the ſilver is thereby accelerated. They alſo hinder in a manner a ſmall burning coal fallen into the crucible, from ſetting the litharge a-boiling, which troubles the operation; for the litharge, or glaſs of lead, eſpecially that which is made without any addition, as ſoon as the phlogiſton enters into it, riſes into a foamy maſs, conſiſting of a multitude of ſmall bubbles very difficult to be confined, unleſs the phlogiſton be entirely conſumed, and the litharge reduced to lead, which ſometimes riſes above the border of the veſſel.

Native metallic ſilver may be ſeparated from the ſtones and earths with which it is intermixed, by amalgamation with mercury, which operation is to be performed in the ſame manner as in the ſeparation of native gold.

ORES OF TIN. The exiſtence of native tin was long a matter of doubt among mineralogiſts. It has nevertheleſs been undoubtedly found in various places. Magellan*, among other ſpecimens, mentions, 1. Malleable tin in a granular form, and alſo foliaceous, bedded in a white hard matter reſembling quartz, but which, on proper examination, proved to be arſenic; a circumſtance that evinces its being native tin, becauſe the arſenic could not have retained this form if the tin had undergone the fuſing heat. It appeared like a thick jagged or ſcolloped lace or edging, and was found at St. Auſtel in Cornwall. 2. In the form of cryſtalline metallic laminæ, or flat cryſtals, riſing ſide by ſide out of an edging, which ſhone like melted tin. They were nearly as thin as the leaves of talc, interſecting each other in various directions, with ſome cavities between them, within which appeared many ſpecks and granules of tin that could be eaſily cut with a knife; this alſo came from Cornwall. 3. In a maſſy form, more than an inch thick in ſome places, and incloſed in a ſtone reſembling quartz, which was taken to be a hard cruſt of cryſtallized arſenic.

The ores of tin hitherto found are in the calciform ſtate. They are remarkable for their great weight, which is between 5,995 and 6,750, according to Kirwan.

The common ore called tin-ſtone has a vitrified appearance, reſembling a garnet of a blackiſh-brown colour, but much heavier. Its ſurface is ſhining, ſometimes ſtriated, and its fracture lamellar; ſoft enough to be cut or ſcraped with a knife, and affording a pale red powder. Some authors aſſert that it contains arſenic, but Kirwan poſitively denies the exiſtence of arſenic as a mineralizer of tin. The Germans call the irregular compact tin ore by the name of zinn-ſtein; but the cryſtallized tin-ſtones are called zinngraupen, if the cryſtals are diſtinct and ſomewhat large. The zinnzwitter ores, in which the cryſtals are ſmall and not ſo diſtinct, reſemble ſmall grains, ſcattered through a compact raw tin-ſtone, or a ſtone of any other kind.

The ſpecies of Corniſh tin ores differ from thoſe of Bohemia and Saxony, by containing much leſs iron, and leſs arſenic; and this is the cauſe of the preference the Engliſh tin in general obtains above any other tin.

The common matrix of tin in theſe mines is the killas and the growan. This conſiſts of white clay mixed with mica and quartz, without any particular texture; which when lamellar and hard, is called gneiſs by the Germans, and is nothing elſe but decayed granite, in which the feltſpar has been broken down to clay.

The zinngraupen from Cornwall. It is the moſt remarkable, though rare, and conſiſts of quadrangular priſms, or double quadrangular pyramids, joined by their baſes, ſo that theſe cryſtals are octoedral; theſe are found at Trwaunanee and Soil-hole, in the pariſh of St. Agnes. Similar priſmatic cryſtals, but of as ſmall a ſize as a hair, are found in tin-ſtone upon killas, at Polgooth, one of the richeſt tin mines, which produces ſometimes a clear profit from 1000 to 1200l. per month.

The ſtream-tin is collected in the valleys of the tin-mountains in Cornwall, and yields a conſiderable quantity of this metal. The ſoil is dug ſeveral feet deep, and waſhed by water going over it, till the heavier particles of the ore remain at the bottom. Theſe are nothing elſe but the abraſions of the tin ores over the mountains, which are rolled down the declivities of the hills to lower grounds.

The ſtream-tin from Penſagillis is remarkable on account of the native gold now and then met with in it; and found, though very rarely, in pieces of the value of two or three pounds ſterling. It principally conſiſts of round, oval, and ſomewhat ſmooth pieces, from the ſize of a bean to that of a pea, and leſs, whoſe poliſhed ſurfaces ſhew a variety of reddiſh, grey, light-brown, and dark-yellow colours.

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* On Cronſtedt, 626.

The wood-tin ore looks like hematites, and is found only in the pariſhes of St. Columb, Roach, and St. Denis. This is without any cryſtallized form, and has a very inconſiderable quantity of iron with it.

Another wood-like tin ore, deſcribed by profeſſor Brunnich, ſhews various fine fibres converging to different centres, like the radiated zeolyte; but is ſo compact and hard, as to ſtrike fire with ſteel. Its ſpecific gravity at the 45° of Fahrenheit is 580, and even 645. It contains ſome arſenic and a conſiderable proportion of iron; and gives ſometimes 63,5 per cent. of tin. It is very ſcarce, and found only in ſmall pieces *.

The tin ſpar, or white tin ore, is generally of a whitiſh or gray colour; ſometimes it is yellowiſh, ſemi-tranſparent, and cryſtallized, either of a pyramidal form, or irregular. It is white and ſemi-tranſparent, reſembling a calcareous or rather ponderous ſpar, but is eaſily known by its great weight and ſhining greaſy appearance. Its fracture alſo is vitreous. It was formerly thought to contain arſenic, but Margraaf found it to be the pureſt of all tin-ores; though it is ſaid to contain ſometimes a mixture of calcareous earth. Its ſpecific gravity is = 6,007.

Tin grains is of a ſpherical polygonal figure, like the garnets; but ſeems more unctuous on its ſurface.

It is found either in large or ſmall grains.

Bergman received a ſpecimen of native aurum muſivum from Nerſchinſkoi in Siberia. It reſembled the artificial aurum muſivum externally, or rather the aurum muſivum formed a cruſt invironing a nucleus radiated in its fracture, and reſembling a white metal. It yielded to the knife, and the place of ſection exhibited variable colours. Its powder was black. By the analyſis, it proved to conſiſt of tin mineralized by ſulphur, with a very ſmall portion of copper. In the Journal de Phyſique for 1783, it is ſaid that the ſpecimen was too ſmall to admit of a determination of the quantities in the large way: but in the preface to the Sciographia it is ſaid that the native aurum muſivum contained forty parts of ſulphur to one of tin; and the other mineral, which reſembled antimony, contained one fifth part of ſulphur only.

At Hael Rock, in St. Agnes in Cornwall, there has been found a metallic vein nine feet wide, at twenty yards beneath the ſurface. Raſpe was the firſt who diſcovered this to be a ſulphurated tin ore: it is very compact, of a blueiſh-white colour, approaching to gray ſteel, and ſimilar to the colour of gray copper-ore: it is lamellar in its texture, and very brittle. It conſiſts of ſulphur, tin, copper, and ſome iron. Raſpe propoſes to call it bell-metal ore.

According to Klaproth's analyſis of this ore, 119 grains contain 30 of pure ſulphur, 41 of tin, 43 of copper, two of iron, and three grains of the ſtony matrix. In another ſpecimen of the ſame ſulphurated tin ore from Cornwall, there were in the hundred, 25 parts of ſulphur, 34 of tin, 36 of copper, three of iron, and two of the ſtony matrix.

Bergman's method of eſſaying tin ores in the humid way is as follows: Let the tin ore, well ſeparated from its ſtony matrix by waſhing, and reduced to the

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* This account of the Corniſh tin ores is extracted from a treatiſe of Klaproth by Magellan.

moſt ſubtile powder, be digeſted in concentrated oil of vitriol in a ſtrong heat for ſeveral hours; then, when cool, add a ſmall quantity of concentrated marine acid, and ſuffer it to ſtand for one or two hours; then add water; and when the ſolution is clear pour it off, and precipitate it by fixed mineral alkali. One hundred thirty-one grains of this precipitate waſhed and dried are equivalent to 100 of tin in its reguline ſtate, if the precipitate conſiſts of pure tin; but if it contains copper or iron, it ſhould be calcined for one hour in a red heat, and then digeſted in nitrous acid, which will take up the copper, and afterwards in marine acid, which will ſeparate the iron.

In the dry way, theſe ores, after pulverization and ſeparation of the ſtony matter by waſhing, are to be melted with a mixture of double their weight of a flux, conſiſting of equal parts of pitch and calcined borax, in a crucible lined with charcoal, and to which a cover is luted; fuſion ſhould be ſpeedily procured.

Bergman recommends a mixture of one part of the ore with two of tartar, one of black flux, and one-half part of roſin: this is to be divided into three parts, and each ſucceſſively projected into a crucible heated white, and immediately covered after the foregoing portion ceaſes to flame: the whole operation takes up but ſeven minutes, or leſs.

Previous to ſmelting in the large way, the impure ores of tin muſt be cleanſed as much as is poſſible from all heterogeneous matters. This cleanſing is more neceſſary in ores of tin than of any other metal, becauſe in the ſmelting of tin ores a leſs intenſe heat muſt be given than is ſufficient for the ſcorification of earthy matters; leſt the tin be calcined. Tin ores previouſly bruiſed may be cleanſed by waſhing, for which operation their great weight and hardneſs render them well adapted. If they be intermixed with very hard ſtones or ferruginous ores, a ſlight roaſting will render theſe impure matters more friable, and conſequently fitter to be ſeparated from the tin ores. Sometimes theſe operations, the roaſting, contuſion, and lotion, muſt be repeated. By roaſting, the ferruginous particles are ſo far revived, that they may be ſeparated by magnets.

The ore, thus cleanſed from adhering heterogeneous matters, is to be roaſted in an oven or reverberatory furnace with a fire rather intenſe than long continued, during which it muſt be frequently ſtirred to prevent its fuſion. By this operation the arſenic is expelled, and in ſome works is collected in chambers built purpoſely above the calcining furnace.

Laſtly, the ore cleanſed and waſhed is to be fuſed, and reduced to a metallic ſtate. In this fuſion, attention muſt be given to the following particulars: 1. No more heat is to be applied than is ſufficient for the reduction of the ore, becauſe this metal is fuſible with very little heat, and is very eaſily calcinable. 2. To prevent this calcination of the reduced metal, a larger quantity of charcoal is uſed in this than in the other fuſions. 3. The ſcoria muſt be frequently removed, leſt ſome of the tin ſhould be involved in it, and the melted ore muſt be covered with charcoal powder to prevent the calcination of its ſurface. 4. No flux or other ſubſtance, excepting the ſcoria of former ſmeltings which contains ſome tin, are to be added, to facilitate the fuſion.

ORES OF URANITE, OR URANIUM. See URANITE.

ORES OF WOLFRAM. See WOLFRAM.

ORES OF ZINC. This metal has not been found in a native ſtate.

All the ores of zinc tinge plates of copper of a yellow colour, when ſtratified with that metal and charcoal; but for this purpoſe the ſulphureous ores muſt be previouſly roaſted. Of the calciform ores of zinc, Kirwan makes four varieties.

Variety I. The vitreous zinc ore, or zinc ſpar, is a pure calx of zinc, of a whitiſh-gray, blueiſh-gray, or yellowiſh colour, and of a hardneſs generally ſufficient to ſtrike fire with ſteel; in its fracture it reſembles quartz, irregular, ſtalactitical or cryſtallized in groups, and weighty; by calcination it loſes one-third of its weight, without emitting a ſulphureous or arſenical ſmell, and is infuſible in the ſtrongeſt heat either ſingly or with mineral alkali, but eaſily fuſible with borax or microcoſmic ſalt. In the mineral acids it is ſoluble with efferveſcence, and with the vitriolic affords vitriol of zinc. One hundred grains of this ore contain about 65 of the calx of zinc, 28 of aerial acid, ſix of water, and one of iron, and ſometimes a little of ſilex.

Bergman ſuſpects the ſubſtance called zinc ſpar by Baron Born to be a different ſubſtance. Bindheim found it inſoluble in acids before calcination, and in the dry way infuſible with the three uſual fluxes, but after calcination it becomes ſoluble in acids *.

Variety II. Tutenago, or the calx of zinc mixed with a notable proportion of iron. Engeſtrom, in the Memoirs of Stockholm for the year 1775, has given us an analyſis of an ore of this ſort from China; it was of a white colour, interſperſed with red ſtreaks of calx of iron, and ſo brittle as to be eaſily broken betwixt the fingers. In the dry way it exhibited the ſame appearances as the former variety, except that it loſt no part of its weight; it was ſoluble in the mineral acids, particularly with the aſſiſtance of heat, and with the vitriolic afforded vitriol both of zinc and iron; the quantity of fixed air was ſo ſmall as to be abſorbed by the ſolution; it contained in various ſpecimens from 60 to 90 per cent. of zinc; the remainder was iron and a ſmall proportion of argill. Bindheim alſo diſcovered this variety in Germany, and found it to conſiſt of zinc, a little iron, and ſilex †.

Variety III. Calamine. In this ore the calx of zinc is mixed with iron and clay in various proportions. Its colour is white, gray, yellow, brown or red, not ſo brittle as the ſecond variety, and of various degrees of hardneſs, though ſcarce ever ſo hard as to ſtrike fire with ſteel; its texture equable or cellular, and its form either irregular, cryſtallized or ſtalactitical; when calcined it loſes no part of its weight, except it be mixed with charcoal, and then flowers of zinc ſublime; it is ſoluble in acids, and with the vitriolic affords vitriol of iron as well as of zinc, which ſhews the iron it contains is not much calcined. The ſpecific gravity of the beſt ſort, that is, the gray, is 5,000 : 100 parts of this afforded Bergman 84 of calx of zinc, three of iron, one of argill, and 12 of ſilex; but in other ſpecimens theſe proportions are very different; ſome ores are ſo poor as not to contain above 4 per cent. of calx of zinc; a good ore ſhould afford at leaſt 30 per cent. and its ſpecific gravity be about 4,400 or 5,000.

Sometimes calamines contain a mixture of calcareous earth and lead. 3 Lin. von Gmel. 112. Moſt of the Engliſh calamines contain lead.

The firſt and ſecond varieties are eaſily analyſed in the moiſt way, by diſſolving them in the dilute vitriolic acid; the ſilex, if any, will remain undiſſolved, and the zinc and iron are taken up, and may be ſeparated by adding a piece of zinc previouſly weighed, and boiling the ſolution; the iron will be precipitated; the ſolution, which then contains only zinc, ſhould be precipitated by aerated mineral alkali. One hundred ninety-three grains of this precipitate are equivalent to 100 of zinc in its metallic form, from which the weight loſt by the inſerted zinc

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* 4 Berlin Schrift, 399. Quoted by Kirwan.

† 4 Berl. Schrift, 400. Quoted by Kirwan.

ſhould be ſubtracted; the weight of the fixed air and water may be collected by comparing the loſs of weight which the ore ſuffers by calcination and ſolution in acids.

The analyſis of the third variety, or calamine, is more complex. Bergman gives us two methods of performing it. The firſt is to dephlogiſticate it in the nitrous acid with the aſſiſtance of heat, and boil away the acid to dryneſs. Repeat this operation twice or thrice, uſing each time twice as much of the acid as the ore weighs; and laſtly, diſſolve all that is ſoluble in a freſh portion of nitrous acid: by this means the zinc (and lead if any) with the argill will be taken up, while the iron, being dephlogiſticated, will with the ſilex remain undiſſolved: if the ſolution contains lead, the marine acid will precipitate it; after which the vitriolic may be uſed to precipitate the calcareous earth, if any be contained in the ore, or the lead and other metals may be precipitated by adding a piece of zinc. The zinc may then be precipitated by the Pruſſian alkali, the weight of which divided by five gives that of zinc in its metallic form contained in the ore. The undiſſolved reſiduum ſhould be treated with three times its weight of concentrated vitriolic acid, and evaporated to dryneſs, and all that is ſoluble extracted with warm water; the iron ſhould be precipitated by the Pruſſian alkali, and the argill by the aerated mineral alkali, which ſhould alſo be added to the nitrous ſolution after the zinc is precipitated.

The ſecond method is ſhorter and more ingenious. He diſtills the vitriolic acid over calamine to dryneſs; the reſiduum he lixiviates in hot water; what remains undiſſolved is ſilex; to the ſolution he adds a cauſtic volatile alkali, which precipitates the iron and argill, but keeps the zinc in ſolution, as it is ſoluble in vitriolic ammoniac; the precipitate he re-diſſolves in vitriolic acid, and ſeparates the iron and argill as before.

VARIETY IV. Zeolytiform. In this ore, the calx of zinc is mixed with a notable proportion of ſilex. The real contents of this ſubſtance were firſt diſcovered by M. Pelletier, a moſt accurate Pariſian chemiſt. It was long taken for a zeolyte, being of a pearl colour, cryſtallized, ſemi-tranſparent, conſiſting of laminæ diverging from different centres, and becoming gelatinous with acids. It was commonly called zeolyte of Friburgh: he found 100 grains of it to contain from 48 to 52 of quartz, 36 of calx of zinc, and eight or 12 of water.

Of the ores of zinc which are mineralized by ſulphur, by means of iron, there are, according to Kirwan, ſeven varieties. Theſe are generally of a lamellar or ſcaly texture, and frequently of a quadrangular form, reſembling galena; they all loſe much of their weight when heated, and burn with a blue flame; their ſpecific gravity is inferior to that of galena. Almoſt all contain a mixture of lead ore; moſt of them exhale a ſulphureous ſmell when ſcraped, or at leaſt when vitriolic or marine acid is dropped on them.

VARIETY I. is of a blueiſh-gray colour, and of a metallic appearance. Its form is generally cubical or rhomboidal, its texture ſcaly or ſteel-grained; by calcination it loſes nearly $\frac{1}{6}$ of its weight; after calcination it is more eaſily ſoluble in the mineral acids. One hundred parts of it afforded Bergman about 52 of zinc, eight of iron, four of copper, 26 of ſulphur, four of water, and ſix of ſilex.

To analyſe this ore in the moiſt way, Bergman firſt expelled the water and part of the ſulphur by diſtillation; the reſiduum he treated with three times its weight of oil of vitriol evaporated to dryneſs; this lixiviated with warm water, left only ſix parts undiſſolved; in this ſolution a poliſhed plate of iron was boiled, which precipitated the copper. He then by means of the phlogiſticated alkali precipitated the zinc and iron. This precipitate being calcined in an open fire, was ſeveral times treated with nitrous acid evaporated to dryneſs, till the iron was perfectly dephlogiſticated; freſh nitrous acid being then added, diſſolved the zinc only, which being precipitated by the Pruſſian alkali, the proportion of zinc, in its metallic ſtate, was found as in the analyſis of the third variety of the calciform ores. Neither metal as contained in the ore is much dephlogiſticated.

Variety II. is black, Pecheblende. This ore is of moderate hardneſs, does not give fire with ſteel, frequently cryſtallized, and then ſometimes tranſparent, or ſemi-tranſparent; when pulverized, it gives a reddiſh powder; when heated, it decrepitates; and if laid on a burning coal, it emits a ſulphureous ſmell, and depoſes white and yellow flowers; it is not magnetic even after torrefaction, but loſes 25 per cent. of its weight. It is frequently mixed with ſilver, arſenic, and other metals. One hundred parts of that of Danemora, examined by Bergman, exhibited 45 of zinc, one of regulus of arſenic, nine of iron, ſix of lead, all ſlightly dephlogiſticated, 29 of ſulphur, ſix of water, and four of ſilex.

This ore he analyſed in the moiſt way after the following manner: Firſt, by diſtillation he obtained the water, regulus of arſenic, and part of the ſulphur; the reſiduum he boiled in marine acid, until all that was ſoluble was taken up. To the ſolution, after its filtration and ſome evaporation, he added vitriolic ammoniac, by whoſe decompoſition vitriol of lead was precipitated in ſome meaſure, and the remainder of it by further evaporation. This being ſeparated, the remainder was evaporated to dryneſs, and treated with nitrous acid, and at laſt calcined to dephlogiſticate the iron; the calx of zinc only was then diſſolved in the nitrous acid, and precipitated by the Pruſſian alkali.

Variety III. is red, or reddiſh; and is the Röd Slag of the Swedes. Its texture is generally ſcaly, ſometimes cryſtallized, and ſemi-tranſparent; it gives fire with ſteel; it does not decrepitate nor ſmoke when heated, yet it loſes about 13 per cent. of its weight by torrefaction.

One hundred parts of that of Sahlberg contained, by Bergman's analyſis, 44 of zinc, five of iron, 17 of ſulphur, five of water, five of argill, and 24 of quartz.

In analyſing this ore, the water and ſulphur were obtained as before; nitrous acid was ſeveral times diſtilled to dryneſs over the reſiduum, which was at laſt calcined, and again treated with the nitrous acid, which then left the iron and quartz and a little argill undiſſolved; the Pruſſian alkali precipitated the zinc from this ſolution, and after that, the aerated volatile alkali precipitated the argill. The undiſſolved reſiduum was treated with oil of vitriol diſſolved to dryneſs, which took up the calx of iron, and a ſmall proportion of argill. The Pruſſian alkali precipitated the iron, and the liquor being then evaporated, afforded a little alum and tartar vitriolate.

Variety IV. is phoſphoreſcent blende. Its colour is generally greeniſh, yellowiſh-green, or red, of different degrees of tranſparency, or opake; when ſcraped with a knife in the dark, it emits light, even in water; and after undergoing a white heat, when diſtilled per ſe, a ſiliceous ſublimate riſes, which ſhews it contains the ſparry acid, probably united to a metal, ſince it ſublimes. It is almoſt wholly ſoluble in the marine acid in a boiling heat.

Bergman found 100 parts of that of Scharfenberg to contain 64 of zinc, five of iron, 20 of ſulphur, four of fluor acid, ſix of water, and one of ſilex.

Variety V. is grayiſh-yellow blende. This conſiſts of a mixture of blende, galena, and petrol; it contains about 24 per cent. of zinc; it is probably the ſame as the gray blende of Monnet. Mineral. p. 400.

Variety VI. is white blende; and is found at Silverberget.

Variety VII. is yellow blende. This ore is of the colour of wax, and ſemi-tranſparent, and contains much ſulphur.

In the dry way zinc is reduced by diſtilling its ore after torrefaction, with a mixture of its own weight of charcoal, in an earthen retort well luted, and a ſtrong heat; but by this method ſcarce half the zinc it contains is obtained.

The firſt dreſſing of calamine for the large works of zinc conſiſts in picking out all the pieces of lead ore, lime, and iron-ſtone, cauk, and other heterogeneous ſubſtances, which are found mixed with it in the mine: it is then calcined in proper furnaces, where it loſes about a fourth or third part of its weight. It is picked out again very carefully, as the heterogeneous particles have become more diſcernible, by the action of the fire; it is then ground to a fine powder, and waſhed in a gentle rill of water, which carries off the earthy mixtures of extraneous matters; ſo that, by theſe proceſſes, a ton weight of the crude calamine of Derbyſhire is reduced to 1200 only.

Bergman affirms, that a certain Engliſhman, whoſe name he does not mention, made, ſeveral years ago, a voyage to China, for the purpoſe of learning the art of ſmelting zinc, or tutenago; and that he became inſtructed in the ſecret, and returned ſafely home.

It is not improbable, but that a fact of this kind may have ſerved to eſtabliſh the manufactory of zinc in England about the year 1743, when Mr. Champion obtained a patent for the making of it, and built the firſt work of the kind near Briſtol. It conſiſts, as Watſon relates, of a circular kind of oven, like a glaſs-houſe furnace, in which were placed ſix pots, of about four feet each in height, much reſembling large oil-jars in ſhape; into the bottom of each pot is inſerted an iron tube, which paſſes through the floor of the furnace, into a veſſel of water. A mixture of the prepared ore is made with charcoal, and the pots are filled with it to the mouth, which are then cloſe ſtopped with ſtrong covers, and luted with clay. The fire being properly applied, the metallic vapour of the calamine iſſues downwards, or per deſcenſum, through the iron tubes, there being no other place through which it can eſcape; and the air being excluded, it does not take fire, but is condenſed in the water into granulated particles; which being remelted, are caſt into ingots, and ſent to Birmingham under the name of zinc or ſpelter; although by this laſt name of ſpelter, only a granulated kind of ſoft braſs is underſtood among the braziers, and others who work in London, uſed to ſolder pieces of braſs together.

Great part of the zinc volatilized by the force of fire, in large furnaces, as thoſe at Goſlar, adheres to their ſides in the form of a whitiſh calx; this is ſcraped off when the furnace is cold, and is called by the name of ofenbruch or cadmia, which is employed, as well as zinc, to make braſs.

ORIENTAL. Precious ſtones from the Eaſt have been ſuppoſed to be harder and more brilliant than thoſe which come from South America. How far this may really be the caſe, is not perhaps eaſy to be determined. Jewellers uſe the words oriental and occidental to denote the ſuperior or inferior quality of a gem, without giving themſelves any trouble about the place it came from. Thus an oriental topaz is one of the beſt, whether it come from the Eaſt Indies or not; and the inferior ſtones or coloured quartz are called occidental topazes, though ſome of them perhaps may come from the Eaſt.

ORIGANUM. An eſſential oil is kept in the ſhops, under the name of the oil of origanum, which is obtained from the leaves of the origanum vulgare Linnæi, or wild marjoram.

ORPIMENT. A combination of the calx of arſenic with ſulphur, of a yellow colour. It is naturally found in the earth, generally of an irregular form, and compoſed of ſhining, flexible laminæ, more or leſs ſolid. Its ſpecific gravity, according to Kirwan, is about 5,315, who aſſerts, that it contains about one tenth of its weight of ſulphur.

The ſame author aſſerts, that the realgar, or red combination of arſenic and ſulphur, contains 16 parts of the latter in the hundred, and has no greater ſpecific gravity than 3,225. This is either opake or ſemi-tranſparent; ſometimes tranſparent, and regularly cryſtallized, in octohedral pyramids or priſms. In this laſt form it is called ruby of arſenic. Chaptal, however, obſerves from Bucquet, that the difference between orpiment and realgar does not conſiſt in the proportion of their component parts, but ſimply in the latter having undergone a greater heat, nothing more being neceſſary in order to convert orpiment into realgar than expoſure to a ſtrong heat; and with the ſame mixture we may at pleaſure obtain either of theſe products, according to the manner of applying the heat. This fact appears to reſemble the converſion of mercurial ethiops into cinnabar. See CINNABAR.

ORRIS. The dry roots of the Florence iris or oris (iris alba Florentina, C. B.) are entirely mild, and ſaid to be a medicine of good ſervice in diſorders of the breaſt. They have a pleaſant ſweet ſmell reſembling that of violets, and hence are employed in ſweet-ſcented powders, for flavouring liquors, &c. The diſtilled water ſmells a little of the root, but exhibits no appearance of oil: the diſtilled ſpirit alſo has ſome ſlight ſmell. The ſtrongeſt preparation both in ſmell and taſte, is the ſpirituous extract, this containing nearly all the active parts of the root concentrated into a ſmall volume. An ounce of the root yielded a dram and 17 grains of ſpirituous, and afterwards a dram and 40 grains of watery extract: water applied at firſt extracted from the ſame quantity three drams, and ſpirit afterwards only eight grains. The extract made by water at firſt both taſtes and ſmells of the orris, though not near ſo ſtrongly as the ſpirituous.

OSTEOCOLLA is a ſubſtance formed by ſtony matters filling up the interſtices of rotten roots of trees. It has been particularly deſcribed by Mr. Gleditſch, and examined chemically by Mr. Margraaf. See Memoirs of the Berlin Academy for the year 1748. The former author relates, that it is dug from grounds containing fine ſand and a fine calcareous earth; and that ſometimes the roots of living trees had been found converted into this ſtony ſubſtance. From Margraaf's experiments it appears, that the oſteocolla examined by him was compoſed of a fine ſand, a fine calcareous earth, and ſome rotten remains of a root. Neumann ſays, that he found marine acid in oſteocolla. But nothing of that or any other acid could be diſcovered by Margraaf. Neumann alſo ſays, that he totally diſſolved oſteocolla by means of dilute vitriolic acid. Hence the ſubſtances examined by theſe two chemiſts ſeem to have been different. Differences muſt ariſe from the different qualities of the ſoil in which oſteocolla is found.

OTTA or ATYR OF ROSES. The eſſential oil of roſes. It comes to us under this name from Bengal, and is of too high price to become an article of commerce in this country. From a variety of accounts we learn that it is obtained in the uſual method, viz. by the diſtillation of roſe leaves with water, and that a prodigious quantity of roſes affords but a ſmall proportion of the oil. It is ſaid to be equal in fragrance to a new blown roſe. This may perhaps be true of the oil when newly diſtilled; but in the few ſpecimens which have come under my obſervation, the difference in ſcent appears to be nearly as great as between moſt other eſſential oils and the vegetables which afford them.

OXYGENE. See Nomenclature.

OXYMEL. A compound of honey and vinegar, uſually with other medical ingredients.

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PALM-OIL. This is obtained from the kernels of the fruit of a ſpecies of palm-tree, which is a native of the coaſt of Guinea and Cape de Verd Iſlands, whence it has been tranſplanted into Jamaica and Barbadoes. The oil as it comes to us is about the conſiſtence of an ointment, and of an orange colour; of a ſtrong though not diſagreeable ſmell, and very little taſte. By long keeping it loſes its colour and becomes white, when it ought to be rejected. It is uſed in external applications, and alſo as a purgative medicine.

PANACEA. This name, which ſignifies univerſal remedy, has been given to various preparations. The panacea of antimony was formed by detonation in ſmall portions at a time in a red-hot crucible, a mixture of ſix parts, by weight, of crude antimony, two of nitre, one and a half of common ſalt, and one of charcoal. The maſs when fuſed and poured out conſiſts of regulus of antimony at bottom; an hepatic compound in the next place; and at top, a ſpungy maſs. This laſt, when pulverized, waſhed, and dried, is of a golden yellow colour, and is the panacea. It was given in pills containing from one tenth to one third of a grain of the powder, and is ſaid to operate gently as a cathartic and emetic.

We have ſeveral mercurial panaceas. The red panacea is made by waſhing the red calx of mercury, obtained by nitrous acid and calcination; then digeſting it for many days in ardent ſpirit; next, burning off from it a portion of tincture of ſulphur; and laſtly, digeſting it again in ardent ſpirit for ſome days.

The white panacea conſiſts of calomel on which ardent ſpirit has been digeſted, and which is afterwards, according to ſome preſcriptions, to be repeatedly ſublimed.

Modern chemiſtry has rejected theſe inartificial, troubleſome, and at beſt, uſeleſs proceſſes.

The magneſian earth obtained by precipitation from the mother water of nitre, was called the nitrous panacea.

PAPER-MARLE. See Marle.

PARGET. The plaſter ſtone or calcareous earth combined with vitriolic acid.

PARIAN MARBLE. A fine white Italian marble, which is never poliſhed when wrought, but only finely ground down. It has a glittering texture, and is ſlightly tranſparent at the edges. Cronſtedt conſiders it as a limeſtone, that is, lime combined with fixed air and water.

PARTING, is an operation by which gold and ſilver are ſeparated from each other. As theſe two metals reſiſt equally well the action of fire and of lead, they muſt therefore be ſeparated by other methods. This ſeparation could not be effected, if they were not ſoluble by different menſtruums.

Nitrous acid, marine acid, and ſulphur, which cannot diſſolve gold, attack ſilver very eaſily; and therefore theſe three agents furniſh methods of ſeparating ſilver from gold, or of the operation called parting.

Parting by nitrous acid is the moſt convenient, and therefore moſt uſed, and even almoſt the only one employed by goldſmiths and coiners. Wherefore it is called ſimply parting. That made with the marine acid is only made by cementation, and is known by the name of concentrated parting. Laſtly, parting by ſulphur is made by fuſion, which the chemiſts call the dry way, and is therefore called dry parting. We ſhall deſcribe each of theſe methods *.

PARTING BY AQUA FORTIS. Although parting by aqua fortis be eaſy, as we have ſaid, it cannot ſucceed, or be very exact, unleſs we attend to ſome eſſential circumſtances.

1. The gold and ſilver muſt be in a proper proportion; for if the gold be in too great quantity, the ſilver would be covered and guarded by it from the action of the acid.

Therefore when eſſayers do not know the proportion of theſe two metals in the maſs to be operated on, they diſcover it by the touch, or aſſay needles. See Assay.

If this trial ſhews, that in any given maſs the ſilver is not to the gold as three to one, this maſs is improper for the operation of parting by aqua fortis. In this caſe, the quantity of ſilver neceſſary to make an allay of that proportion muſt be added.

This operation is called quartation, probably becauſe it reduces the gold to a fourth part of the whole maſs.

2. That the parting may be exact, the nitrous acid or aqua fortis employed muſt be very pure, and eſpecially free from mixture of vitriolic and marine acids. Its purity muſt therefore be aſcertained; and if this be found not ſufficient, the acid muſt be purified by ſolution of ſilver. See Acid of Nitre, p. 32.

If the purity of the aqua fortis were not attended to, a quantity of ſilver proportionable to theſe two foreign acids would be ſeparated during the ſolution; and this portion of ſilver converted by theſe acids to vitriol of ſilver, and to luna cornea, would remain mingled with the gold, which conſequently would not be entirely purified by the operation.

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* From Macquer.

When the metallic maſs is properly allayed, it is to be reduced to plates, rolled up ſpirally, called cornets; or to grains. Theſe are to be put into a matraſs, and upon them a quantity of aqua fortis is to be poured, the weight of which is to that of the ſilver as three to two: and as the nitrous acid employed for this operation is rather weak, the ſolution is aſſiſted, eſpecially at firſt, by the heat of a ſand-bath, in which the matraſs is to be placed. When, notwithſtanding the heat, no further mark of ſolution appears, the aqua fortis charged with ſilver is to be decanted. Freſh nitrous acid is to be poured into the matraſs, ſtronger than the former, and in leſs quantity, which muſt be boiled on the reſiduous maſs, and decanted as the former. Aqua fortis muſt even be boiled a third time on the remaining gold, that all the ſilver may be certainly diſſolved. The gold is then to be waſhed with boiling water. This gold is very pure, if the operation has been performed with due attention. It is called gold of parting.

No addition of ſilver is required, if the quantity of ſilver of the maſs is evidently much more conſiderable than that of the gold: perſons who have not proof needles, and other apparatus to determine the proportion of the allay, may add to the gold an indeterminate quantity of ſilver, obſerving that this quantity be rather too great than too ſmall, and ſo conſiderable as to render the maſs nearly as white as ſilver; for a large quantity of ſilver is rather favourable than hurtful to the operation: it has no other inconvenience than an uſeleſs expence, as the larger the quantity is of ſilver, the more aqua fortis muſt be employed. We ought to attend to this fact, that the colour of gold is ſcarcely perceptible in a maſs two-thirds of which is ſilver and one-third is gold; this colour then muſt be much leſs perceptible when the gold is only one-fourth part, or leſs, of the whole maſs.

If the quantity of gold exceeds that of the ſilver, the maſs may be expoſed to the action of aqua regia, which would be a kind of inverſe parting, becauſe the gold is diſſolved in that menſtruum, and the ſilver is not, but rather reduced to a luna cornea, which remains in form of a precipitate after the operation. But this method is not much practiſed, for the following reaſons.

Firſt, the gold cannot be eaſily ſeparated from the aqua regia; for if the parting has been made with an aqua regia prepared with ſal ammoniac, or if the gold be precipitated by a volatile alkali, this gold has a fulminating quality, and its reduction requires particular operations. If the aqua regia has been made with ſpirit of ſalt, and the precipitation effected by a fixed alkali, the gold will not then be fulminating, but the precipitation will be very ſlow, and probably not complete. See Gold.

Secondly, in the parting by aqua regia, the ſilver is indeed precipitated into a luna cornea, and thus ſeparated; but this ſeparation is not perfect, as a ſmall quantity of luna cornea will always remain diſſolved by the acids, if this ſolution even could only be effected by the ſuperabundant water of theſe acids. Accordingly the ſilver is not ſo accurately ſeparated from the gold by aqua regia, as the gold is from the ſilver by aqua fortis. We ſhall afterwards ſee, at the article Parting (Concentrated), that by this operation, ſilver may be ſeparated from gold in the dry way without the neceſſity of quartation, although theſe metals ſhould not be in a proper proportion for the parting by aqua fortis.

The gold after the parting by aqua fortis is much more eaſily collected when it remains in ſmall maſſes, than when it is reduced to a powder.

When the maſs has been regularly quarted, that is, when it contains three parts of ſilver and one part of gold, we muſt employ, particularly for the firſt ſolution, an aqua fortis ſo weakened, that heat is required to aſſiſt the ſolution of the ſilver: by which means the ſolution is made gently; and the gold which remains preſerves the form of the ſmall maſſes before the ſolution. If the aqua fortis employed were ſtronger, the parts of the gold would be diſunited, and reduced to the form of a powder, from the activity with which the ſolution would be made.

We may indeed part by aqua fortis a maſs containing two parts of ſilver to one part of gold; but then the aqua fortis muſt be ſtronger; and if the ſolution be not too much haſtened, the gold will more eaſily remain in maſſes after the operation. In both caſes, the gold will be found to be tarniſhed and blackened. Its parts have no adheſion together, becauſe the ſilver diſſolved from it has left many interſtices; and the cornets or grains of this gold will be eaſily broken, unleſs they be handled very carefully. To give them more ſolidity, they are generally put into a teſt under a muffle, and made red-hot, during which operation they contract conſiderably, and their parts are approximated. Theſe pieces of gold are then found to be rendered much more ſolid, ſo that they may be handled without being broken. By this operation alſo the gold reſumes its colour and luſtre; and as it generally has the figure of cornets, it is called gold in cornets, or grain gold. Eſſayers avoid melting it, as they chooſe to preſerve this form, which ſhews that it has been parted.

The gold and ſilver thus operated upon ought to have been previouſly refined by lead, and freed from all allay of other metallic matters, ſo that the gold which remains ſhould be as pure as is poſſible. However, as this is the only metal which reſiſts the action of aqua fortis, it might be purified by parting from all other metallic ſubſtances; but this is not generally done for ſeveral reaſons. Firſt, becauſe the refining by lead is more expeditious and convenient for the ſeparation of the gold from the imperfect metals; and ſecondly, becauſe the ſilver, when afterwards ſeparated from the aqua fortis, is pure; laſtly, becauſe moſt imperfect metals do not remain completely and entirely diſſolved in nitrous acid, from the degree of calcination produced in them by this acid, the gold would be found, after the parting, mixed with the part of theſe metals which is precipitated.

The gold remaining after the parting ought to be well waſhed, to cleanſe it from any of the ſolution of ſilver which might adhere to it; and for this purpoſe diſtilled water ought to be uſed, or at leaſt water the purity of which has been aſcertained by its not forming a precipitate with a ſolution of ſilver, becauſe ſuch a precipitate would alter the purity of the gold.

The ſilver diſſolved in the aqua fortis may be ſeparated either by diſtillation, in which caſe all the aqua fortis is recovered very pure, and fit for another parting; or it may be precipitated by ſome ſubſtance which has a greater affinity than this metal with nitrous acid. Copper is generally employed for this purpoſe at the mint.

The ſolution of ſilver is put into copper veſſels. The aqua fortis diſſolves the copper, and the ſilver precipitates. When the ſilver is all precipitated, the new ſolution is decanted, which is then a ſolution of copper. The precipitate is to be well waſhed, and may be melted into an ingot. It is called parted ſilver. When this ſilver has been obtained from a maſs which had been refined by lead, and when it has been well waſhed from the ſolution of copper, it is very pure.

Cramer juſtly obſerves, in his Treatiſe on Eſſaying, that however accurately

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the operation of parting has been performed, a ſmall portion of ſilver always remains united with the gold, if the parting has been made by aqua fortis; or a ſmall portion of the gold remains united with the ſilver, if the parting has been made by aqua regia; and he eſtimates this ſmall allay to be from a two hundredth to a hundred and fiftieth part, which quantity may be conſidered as nothing for ordinary purpoſes, but may become ſenſible in accurate chemical experiments.

The maſs of gold and ſilver to be quarted, ought previouſly to be granulated, which may be done by melting it in a crucible, and pouring it into a large veſſel full of cold water, while at the ſame time a rapid circular motion is given to the water by quickly ſtirring it round with a ſtick or broom.

The veſſels generally uſed for this operation, called parting-glaſſes, have the form of truncated cones, the bottom being commonly about ſeven inches wide, the aperture about one or two inches wide, and the height about twelve inches. Theſe glaſs veſſels ought to have been well annealed, and choſen free from flaws; as one of the chief inconveniences attending the operation is, that the glaſſes are apt to crack, by expoſure to cold, and even when touched by the hand. Some operators ſecure their glaſſes by a coating. For this purpoſe, they ſpread a mixture of quick-lime ſlaked with beer and whites of eggs upon linen cloth, which they wrap round the lower part of the veſſel, leaving the upper part uncovered, that they may ſee the progreſs of the operation, and over this cloth they apply a compoſition of clay and hair. Schlutter adviſes to put the parting-glaſſes in copper veſſels containing ſome water, and ſupported by trevets, with fire under them. When the heat communicated by the water is too great, it may be diminiſhed by adding cold water, which muſt be done, very carefully, by pouring againſt the ſides of the pan, to prevent too ſudden an application of cold to the parting-glaſs. The intention of this contrivance is, that the contents of the glaſſes, if theſe ſhould break, may be received by the copper veſſel. Into a glaſs fifteen inches high, and ten or twelve inches wide at bottom, placed in a copper pan twelve inches wide at bottom, fifteen inches wide at top, and ten inches high, he uſually put about eighty ounces of metal, with twice as much aqua fortis.

The aqua fortis ought to be ſo ſtrong as to be capable of acting ſenſibly on ſilver when cold, but not ſo ſtrong as to act violently.

If the aqua fortis be very ſtrong, however pure, and if the veſſels be well cloſed, a ſmall quantity of the gold will be diſſolved along with the ſilver, which is to be guarded againſt.

Little heat ought to be applied at the beginning, the liquor being apt to ſwell, and riſe over the veſſel; but when the acid is nearly ſaturated, the heat may be ſafely increaſed.

When the ſolution ceaſes, which may be known by the diſcontinuance of the effervеſcence, or emiſſion of air-bubbles, the liquor is to be poured off. If any grains appear entire, more aqua fortis muſt be added, that all the ſilver may be diſſolved. If the operation has been performed ſlowly, the remaining gold would have ſtill the form of diſtinct maſſes, which are to receive ſolidity and colour by fire, as Macquer directs. If the operation has been performed haſtily, the gold will have the appearance of a black mud or powder, which after five or ſix waſhings with pure water muſt be melted.

The ſilver is uſually recovered by precipitating it from the aqua fortis by means of copper veſſels into which the liquor is poured, or of plates of copper which are thrown along with the liquor into glaſs veſſels. A conſiderable heat is required to accelerate this precipitation. Dr. Lewis ſays, he has obſerved, that when the aqua fortis was perfectly ſaturated with ſilver, no precipitation was occaſioned by plates of copper, till a drop or two of aqua fortis was added to the liquor, and then the precipitation began and continued as uſual.

The precipitated ſilver muſt be well waſhed in boiling water, and fuſed with ſome nitre, the uſe of which is, to ſcorify any cupreous particles which may adhere to the ſilver.

From the ſolution of copper in aqua fortis, a blue pigment, called verditer, is obtained by precipitation with whiting. See Verditer.

PARTING (CONCENTRATED.) Concentrated parting is alſo called parting by cementation, becauſe it is actually performed by cementation. This parting or purification of gold is uſed when the quantity of it is ſo great in proportion to the ſilver, that it cannot be ſeparated by aqua fortis. This operation is performed in the following manner:

A cement is firſt prepared, compoſed of four parts of bricks powdered and ſifted, of one part of green vitriol calcined till it becomes red, and of one part of common ſalt. The whole is very accurately mixed together, and a firm paſte is made of it by moiſtening it with a little water or urine. This cement is called cement royal, becauſe it is employed to purify gold, which is conſidered by chemiſts as the king of metals.

The gold to be cemented is to be reduced to plates as thin as ſmall pieces of money. At the bottom of the crucible, or cementing pot, a ſtratum of cement, of the thickneſs of a finger, is to be put, which is covered with plates of gold: upon theſe another ſtratum of cement is to be laid; and then more plates of gold, till the crucible or pot is filled with theſe alternate ſtrata of cement and of gold. The whole is then to be covered with a lid, which is to be luted with a mixture of clay and ſand. This pot is to be placed in a furnace, or oven, and heated by degrees, till it is moderately red, which heat is to be continued during twenty-four hours. The heat muſt not be ſo great as to melt the gold. The pot or crucible is then left to cool, and the gold is to be carefully ſeparated from the cement, and boiled at different times in a large quantity of pure water. This gold is to be eſſayed upon a touch-ſtone or otherwiſe; and if it be found not ſufficiently purified, it is to be cemented a ſecond time in the ſame manner.

The acid of the common ſalt is diſengaged during this cementation, and diſſolves the ſilver allayed with the gold, by which means it is ſeparated.

This experiment proves, that although marine acid while it is liquid cannot attack ſilver, it is nevertheleſs a powerful ſolvent of that metal. But, for this purpoſe, it muſt be applied to the ſilver in the ſtate of vapours extremely concentrated, and aſſiſted with a conſiderable heat. All theſe circumſtances are united in the concentrated parting.

This experiment proves alſo, that notwithſtanding all theſe circumſtances, which favour the action of the marine acid, it is incapable of diſſolving gold.

Laſtly, the marine acid in this ſtate more effectually diſſolves the ſilver than the nitrous acid does in the parting by aqua fortis, ſince this operation ſucceeds well when the ſilver is in ſo ſmall a proportion as that it would be protected from the action of the nitrous acid in the ordinary parting.

Inſtead of ſea ſalt, nitre may be uſed with equal ſucceſs; becauſe the nitrous acid is then put in a ſtate to attack the ſilver, notwithſtanding the quantity of gold which covers it.

Several chemiſts and artiſts uſe both nitre and common ſalt in the cement royal; which ſhews that the acid of aqua regia, if produced and applied in this manner at the ſame time to gold and ſilver, attacks the latter metal preferably to the former. By this method ſome of the gold would probably be diſſolved along with the ſilver. As no advantages are ſaid to attend it, to give it preference to cementation with nitre or with ſea ſalt ſingly, Dr. Lewis judiciouſly diſapproves of it.

The gold muſt be very carefully waſhed after the operation to cleanſe it from particles of diſſolved ſilver, which otherwiſe would ſtick to it.

The ſilver may be ſeparated from the cement by fuſion with a ſufficient quantity of lead and litharge, and by cupelling the lead which retains the ſilver.

Gold is never purified by one operation of this kind. It muſt therefore be again melted, beat into plates, and cemented as before. The operation is troubleſome, and is now little uſed, except by artiſts in the ſmall way, for extracting ſilver or baſe metals from the ſurface of gold, and thus giving to an alloyed metal the colour and appearance of pure gold.

PARTING (DRY). Dry parting, or parting by fuſion, is performed by ſulphur, which has the property of uniting eaſily with ſilver, while it does not attack gold.

This method of ſeparating theſe two metals would be the cheapeſt, the moſt expeditious and convenient of any, if the ſulphur could diſſolve the ſilver, and ſeparate it from the gold as well and as eaſily as nitrous acid does: but, on the contrary, we are obliged to employ particular treatment, and a kind of concentration, to begin the union of the ſulphur with the ſilver allayed with gold. Then repeated and troubleſome fuſions muſt be made, in each of which we are obliged to add different intermediate ſubſtances, and particularly the metals which have the ſtrongeſt affinity with ſulphur, to aſſiſt the precipitation, which in that caſe does not give a regulus of pure gold, but a gold ſtill allayed with much ſilver, and even with a part of the precipitating metals; ſo that, to complete the operation, cupellation is neceſſary, and alſo parting by aqua fortis.

Hence Macquer infers, that this operation ought not to be made but when the quantity of ſilver with which the gold is allayed is ſo great, that the quantity of gold which might be obtained by the ordinary parting is not ſufficient to pay the expences, and that it is only proper for concentrating a larger quantity of gold in a ſmaller quantity of ſilver. As this dry parting is troubleſome, and even expenſive, it ought not to be undertaken but on a conſiderable quantity of ſilver allayed with gold. Accordingly, Cramer, Schlutter, Schindler, and all good chemiſts and artiſts who have given proceſſes for the dry parting, recommend its uſe only in the abovementioned caſes: it would be much more advantageous, if it could be done by two or three fuſions, and if by theſe an exact ſeparation could be obtained of a ſmall quantity of gold mixed with a large quantity of ſilver.

The moſt advantageous method of ſeparating a ſmall portion of gold* from a large one of ſilver appears to be by means of ſulphur, which unites with and ſcorifies the ſilver without affecting the gold: but as ſulphurated ſilver does not flow thin enough to ſuffer the ſmall particles of gold diffuſed through it to reunite and ſettle at the bottom, ſome addition is neceſſary for collecting and carrying them down.

In order to the commixture with the ſulphur, fifty or ſixty pounds of the mixed metal, or as much as a large crucible will receive, are melted at once, and reduced into grains by lading out the fluid matter, with a ſmall crucible made red hot, and pouring it into cold water ſtirred with a rapid circular motion. From an eighth to a fifth of the granulated metal, accordingly as it is richer or poorer in gold, is reſerved; and the reſt well mingled with an eighth of powdered ſulphur. The grains enveloped with the ſulphur are again put into the crucible, and the fire kept gentle for ſome time, that the ſilver, before it melts, may be thoroughly penetrated by the ſulphur: if the fire were haſtily urged, great part of the ſulphur would be diſſipated without acting upon the metal.

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* Keir's Notes to Macquer's Dictionary.

If to ſulphurated ſilver in fuſion pure ſilver be added, the latter falls to the bottom, and forms there a diſtinct fluid, not miſcible with the other. The particles of gold, having no affinity with the ſulphurated ſilver, join themſelves to the pure ſilver, wherever they come in contact with it, and are thus transferred from the former into the latter, more or leſs perfectly according as the pure ſilver was more or leſs thoroughly diffuſed through the mixed. It is for this uſe that a part of the granulated metal was reſerved. The ſulphurated maſs being brought into perfect fuſion, and kept melted for near an hour in a cloſe covered crucible, one third of the reſerved grains is thrown in; and as ſoon as this is melted, the whole is well ſtirred, that the freſh ſilver may be diſtributed through the mixed, to collect the gold from it. The ſtirring is performed with a wooden rod; an iron one would be corroded by the ſulphur, ſo as to deprive the mixed of its due quantity of ſulphur, and likewiſe render the ſubſequent purification of the ſilver more troubleſome. The fuſion being continued an hour longer, another third of the unſulphurated grains is added, and an hour after this the remainder; after which the fuſion is further continued for ſome time, the matter being ſtirred at leaſt every half hour from the beginning to the end, and the crucible kept cloſely covered in the intervals.

The ſulphurated ſilver appears in fuſion of a dark brown colour: after it has been kept melted for a certain time, a part of the ſulphur having eſcaped from the top, the ſurface becomes white, and ſome bright drops of ſilver, about the ſize of peas, are perceived on it. When this happens, which is commonly in about three hours after the laſt addition of the reſerved grains, ſooner or later according as the crucible has been more or leſs cloſely covered, and the matter more or leſs ſtirred, the fire muſt be immediately diſcontinued; for otherwiſe more and more of the ſilver, thus loſing its ſulphur, would ſubſide and mingle with the part at the bottom in which the gold is collected. The whole is poured out into an iron mortar greaſed and duly heated; or if the quantity is too large to be ſafely lifted at once, a part is firſt laded out from the top with a ſmall crucible, and the reſt poured into the mortar. The gold, diffuſed at firſt through the whole maſs, is now found collected into a part of it at the bottom, amounting only to about as much as was reſerved unſulphurated. This part may be ſeparated from the ſulphurated ſilver above it by a chiſel and hammer; or more perfectly, the ſurface of the lower maſs being generally rugged and unequal, by placing the whole maſs with its bottom upwards in a crucible: the ſulphurated part quickly melts, leaving unmelted that which contains the gold, which may thus be completely ſeparated from the other. The ſulphurated ſilver is eſſayed, by keeping a portion of it in fuſion in an open crucible, till the ſulphur is diſſipated; and then diſſolving it in aqua fortis. If it ſhould ſtill be found to contain any gold, it is to be melted again; as much more unſulphurated ſilver is to be added as was employed in each of the former injections, and the fuſion continued about an hour and a half.

The gold thus collected into a part of the ſilver may be further concentrated into a ſmaller part, by granulating the maſs and repeating the whole proceſs.

The operation may be again and again repeated, till ſo much of the ſilver is ſeparated, that the remainder may be parted by aqua fortis, without too much expence.

The foregoing proceſs, according to Mr. Schlutter, is practiſed at Rammelſberg, in the lower Hartz. The prevailing metal in the ore of Rammelſberg is lead; the quantity of lead is at moſt forty pounds in a quintal, or one hundred pounds of the ore. The lead worked off on a teſt or concave hearth yields about a hundred and ten grains of ſilver, and the ſilver contains only a three hundred and eighty-fourth part of gold; yet this little quantity of gold, amounting ſcarcely to a third of a grain in a hundred weight of the ore, is thus collected with profit. The author above mentioned confines this method of ſeparation to ſuch ſilver as is poor in gold, and reckons parting with aqua fortis more advantageous where the gold amounts to above a ſixty-fourth of the ſilver: he adviſes alſo not to attempt concentrating the gold too far, as a portion of it will always be taken up again by the ſilver. Mr. Scheffer, however, relates (in the Swediſh Memoirs for the year 1752), that he has by this method brought the gold to perfect fineneſs; and that he has likewiſe collected all the gold which the ſilver contained; the ſilver of the laſt operations, which had taken up a portion of the gold, being reſerved to be worked over again with a freſh quantity of gold-holding ſilver. The ſulphurated ſilver is purified by continuing it in fuſion for ſome time with a large ſurface expoſed to the air; the ſulphur gradually exhales, and leaves the ſilver entire.

PARTING BY KEIR's COMPOUND ACID. See Silver.

PEARL ASH. An impure alkali obtained by lixiviation from the aſhes of plants. Mr. Kirwan * examined the Dantzic pearl-aſh. It is exceedingly white, and if not expoſed to the air very hard. Its taſte is alkaline. The contents of various ſpecimens were different, but at a medium he found the pound troy to conſiſt of

Fixed air — —	1290 grains
Moiſture — —	414
Vitriolated tartar — —	505
Digeſtive ſalt and tartar —	36
Earth — — —	38
Alkali — —	3477
	4760

As the examination of the alkalis of commerce muſt be of great utility to the manufacturer, but is very tedious in the way of ſolution and evaporation, Mr. Kirwan propoſes a teſt by the precipitation of the earth from alum by ſolutions of theſe ſalts.

To diſcover whether any quantity of fixed alkali worth attention exiſts in any ſaline compound, diſſolve one ounce of it in boiling water, and into this ſolution let fall a drop of the ſolution of corroſive ſublimate. This will be converted into a brick colour if an alkali be preſent, or into a brick colour mixed with yellow if the ſubſtance contained lime.

But the ſubſtances uſed by bleachers being always impregnated by an alkali, the above trial is in general ſuperfluous, except for the purpoſe of detecting

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* Iriſh Tranſactions 1789.

lime. The quantity of alkali is therefore what they ſhould chiefly be ſolicitous to determine : and for this purpoſe,

1. Procure a quantity of alum, ſuppoſe one pound, reduce it to powder, waſh it in cold water, and then put it into a tea-pot, pouring on it three or four times its weight of boiling water.

2. Weigh an ounce of the aſh or alkaline ſubſtance to be tried, powder it, and put it into a Florence flaſk with one pound of pure water (common water boiled for a quarter of an hour, and afterwards filtered through paper, will anſwer) if the ſaline ſubſtance to be examined be of the nature of barilha or pot-aſh, or half a pound of water if it contain but little earthy matter or pearl-aſh. Let them boil for a quarter of an hour; when cool, let the ſolution be filtered into another Florence flaſk.

3. This being done, gradually pour this ſolution of alum hot into the alkaline ſolution alſo heated. A precipitation will immediately appear. Shake them well together, and let the effervefcence, if any, ceaſe before more of the aluminous ſolution be added. Continue the addition of the alum until the mixed liquor, when clear, turns ſyrup of violets, or paper tinged blue by radiſhes or by litruus, red. Then pour the liquor and precipitate on a paper filtre placed in a glaſs funnel, and the precipitated earth will remain on the filtre. Pour on this a pound or more of hot water gradually, until it becomes taſteleſs. Take up the filtre acid, and let the earth dry in it until they ſeparate eaſily. Then put the earth into a cup of Staffordſhire ware, place it on hot ſand, and dry the earth until it no longer adheres either to glaſs or iron ; then reduce it to powder in the cup with the glaſs peſtle, and keep it a quarter of an hour in a heat from 470° to 500°.

4. The earth being thus dried, throw it into a Florence flaſk, and weigh it ; then put about an ounce of ſpirit of ſalt into another flaſk, and place this in the ſame ſcale as the earth, and counterbalance both in the oppoſite ſcale : this being done, pour the ſpirit of ſalt gradually into the flaſk that contains the earth ; and when all effervefcence is over (if there be any) blow into the flaſk, and obſerve what weight muſt be added to the ſcale containing the flaſks to reſtore the equilibrium ; ſubtract this weight from that of the earth, the remainder is a weight exactly proportioned to the weight of mere alkali of that particular ſpecies which is contained in one ounce of the ſubſtance examined ; all beſide is ſuperfluous matter.

Kirwan remarks that alkalies of the ſame ſpecies may thus be directly compared, becauſe alkalies of different ſpecies cannot but require the intervention of another proportion ; and the reaſon he gives is, becauſe equal quantities of alkalies of different ſpecies precipitate unequal quantities of earth of alum. Thus 100 parts by weight of mere vegetable alkali precipitate 78 of earth of alum ; but 100 parts of mineral alkali precipitate 170,8 parts of that earth. Therefore the precipitation of 78 parts of earth of alum by vegetable alkali, denotes as much of this as the precipitation of 170,8 of that earth by the mineral alkali denotes of the mineral alkali. Hence the quantities of alkali in all the different ſpecies of pot-aſhes, pearl-aſhes, weed or wood-aſhes, may be immediately compared by the above teſt, as they all contain the vegetable alkali ; and the different kinds of kelp or kelps manufactured in different places, and the different ſorts of barilha, may be thus compared, becauſe they all contain the mineral alkali ; but kelps and pot-aſhes, as they contain different ſorts of alkali, can only be compared together by means of the proportion above indicated.

The application of this teſt is founded on the following principles :

1. That a hot ſolution of a free alkali, or of an alkali combined only with

fixed air or ſulphur, can hold no terrene or metallico-neutral ſalt in ſolution; though it may alkalino-neutral ſalt or quicklime, if the alkali be free from fixed air.

2. That earth of alum cannot be precipitated either totally or partially by the hot ſolutions of any alkalino-neutral ſalts, and therefore that its precipitation is always due to the preſence of a free alkali, or at leaſt of an alkali combined only with fixed air or ſulphur, to whoſe quantity it is always proportional. It is true, quick-lime will alſo decompoſe alum; but the preſence of quick-lime is eaſily diſcovered by the addition of a few drops of any mild alkaline ſolution, and by the ſame means as eaſily ſeparated.

3. That if the earth of alum takes up fixed air (which would increaſe its weight), this air will be ſeparated by the heat employed in drying it, or at leaſt by the ſpirit of ſalt poured upon it.

Kirwan ſays, he can ſee but one inaccuracy attending this teſt, and that of little moment; it is this, if the alkali contains ſulphur, this will alſo be precipitated with the earth of alum, and increaſe its weight. The limits of this inaccuracy, at leaſt in common caſes, ſcarcely reach two or three grains, as we ſhall preſently find.

Sulphur is eaſily detected in any alkaline ſolution, by ſaturating it with an acid; hepatic air is generally developed, and the liquor becomes troubled.

Not only the proportion, but alſo the abſolute weight of alkali in different alkaline ſubſtances or aſhes, may be found by this teſt. Attention muſt be paid to the nature of the alkali, and the quantity of earth; a determinate portion will throw down, which muſt be aſcertained as to the firſt by experiment, and as to the latter by fundamental trials.

PEARLS. From the beauty, luſtre and ſcarcity of this animal product, it has obtained a place among precious ſtones, though it poſſeſſes none of their hardneſs. It is a calculus or morbid concretion produced in a certain ſhell-fiſh of the oyſter kind, and ſometimes in common oyſters and muſcles. It is ſometimes found upon the inſide of the ſhell, and ſometimes in the body of the animal.

The mother of pearl fiſh, or pearl oyſter, is an inhabitant of the bottom of the ſea, where it remains fixed, and is not to be had but by diving. A number of ſmall ſhips is generally engaged together in this dangerous buſineſs, on ſuch particular ſpots as have been found to be rich in the pearl fiſh, and at certain ſeaſons of the year. The divers, according to Neumann, are let down by ropes, and immediately drawn up again upon their pulling a bell as a ſignal for that purpoſe. Machines have been contrived for enabling divers to remain ſome time at the bottom, with a ſupply of air, beneath a large veſſel called the diving-bell, or by means of tubes; but it does not appear that they have been received into uſe in the pearl fiſhery. Suffocation is not, however, the only danger to which the divers are expoſed. They are ſubject to ruptures of ſome of the veſſels, from the vaſt preſſure of the water at great depths, and to be wounded or devoured by fiſhes of prey, which ſome of the rich beds of pearl fiſh are ſo much infeſted with, that ſcarcely any one can venture down at all.

After the pearl oyſters are thus got up, there ſtill remains a proceſs not a little prejudicial to the health, and extremely offenſive. If the ſhells were opened directly by any violent means, the pearl, ſaid to be at this time in a ſomewhat ſoft ſtate, would be liable to be injured, and become of little value. The whole are therefore laid in heaps till the ſhells open ſpontaneouſly, and the fiſh putrefies: after which, the corrupted cadaverous matter is ſearched diligently for the pearls, which are often too few to pay the expence of the proprietor, much leſs to make any recompenſe to the workmen for a ſervice ſo loathſome and ſo hazardous.

Pearls are generally divided into oriental and occidental, more from their qualities than the place of produce, the oriental being reckoned the beſt, as for the moſt part they are. The principal oriental pearl fiſheries are in the Perſian Gulph, and on the coaſts of Perſia and Arabia ; near the iſlands of Ceylon, Manaar, Sumatra, Java, and Borneo ; on ſome of the coaſts of Japan ; between Banana and Cochin ; off Cape Comorin, and in other parts along the Malabar coaſt, as particularly at Tutticorin, where there is an excellent pearl bank in poſſeſſion of the Dutch. The moſt remarkable pearl fiſheries of America are in the gulph of Mexico, along the coaſt of New Spain ; off St Margarite or the Pearl Iſland; in the Rio de la Hacha, at the iſlands of St. Martha, Quibo, Gorgonia, &c. In Europe, pearls are occaſionally found on the coaſts of Scotland, Livonia, Courland, in the river Ilts in Bohemia, in the Regen in Bavaria, in certain lakes near Augſberg, and in various other places.

There are pearls of various colours, figures and magnitudes, of an exquiſite ſilver-like brightneſs, ſemi-tranſparent, opake, opal coloured, yellow, greeniſh, blueiſh, grayiſh, reddiſh, browniſh, blackiſh, rainbow-coloured; round, oval, conical, cylindrical, angular; from the ſize of a millet-ſeed or leſs, to that of a hazel nut or more. It is obſervable, that the larger ones approach generally to the figure of a pear. The largeſt pearl hitherto known is deſcribed by Tavernier, in the poſſeſſion of the king of Perſia. It was bought by him at the fiſhery of Catifa in Arabia, for the ſum of 32,000 tomans, or above 110,000l. ſterling. It is in the ſhape of a pear, very regular, and without fault. The diameter, meaſured on the engraving in Tavernier's Travels, is 0.63 Engliſh inch at the largeſt part, and the length 1.3 inch. Another pearl, belonging to the Great Mogul, and perfectly round, mentioned by the ſame author as the largeſt in the world of that figure, meaſures 0.62 Engliſh inch in diameter. Neumann mentions a pearl he ſaw in the Engliſh crown, ſaid to be worth 10,000l. ſterling.

Pearls are valued for their roundneſs, their ſize, and their water, that is, their luſtre and purity. Their weight is eſtimated in Europe by carats, in Perſia by abas's, and in Golconda and Viſapour by ratis, each abas and rati being one eighth part leſs than a carat. The weight of ſmall pearls is expeditiouſly aſcertained, by a braſs inſtrument with holes of different ſizes; ſo that the weight of a pearl is known from the hole it fits. Small irregular pearls are valued from the number that make up an ounce. Neumann gives the following rates: If an hundred makes an ounce, they are valued at one hundred rix-dollars; if the number be leſs, the price is greater ; if the number be greater, the price is leſs. Two hundred to the ounce coſt but ſeventy rix dollars ; three hundred, fifty ; nine hundred, ten ; two thouſand, three ; four thouſand, two and a half. Of the very ſmall ſort, called ſeed pearls, uſed in medicine, an ounce uſually contains eight or ten thouſand, and coſts, if the pearls are of the oriental kind, two rix-dollars ; if occidental, one rix-dollar and twelve gros. The rix dollar is four ſhillings and ſix-pence, and the gros about two-pence.

Attempts have been made to take out ſtains from pearls, and to render the foul opake-coloured pearls equal in beauty to the oriental. Abundance of proceſſes not to be depended on are found in books of receipts and travels. Pearls may be cleaned from external foulneſs by waſhing with a little Venice ſoap and warm water, or ground rice and ſalt, with ſtarch and powder blue, with plaſter of Paris, with white coral, with white vitriol and tartar, with cuttle bone, pumice ſtone, and other ſimilar ſubſtances. But it is not practicable to take out a ſtain which reaches deep into the ſubſtance of the pearl. Nor can a number of ſmall pearls be united, as ſome pretend, into a maſs ſimilar to an entire natural one.

Succeſsful attempts have nevertheleſs been made to form artificial compoſitions, ſo greatly reſembling natural pearls, as not to be diſtinguiſhed from natural pearls, except in their magnitude and apparent perfection. Reaumur has given a memoir on this ſubject in thoſe of the French Academy for 1716. The ingredient for giving the colour is a fine ſilver-like ſubſtance found upon the underſide of the ſcales of the blay or bleak-fiſh. The ſcales taken off in the uſual manner, are waſhed and rubbed with freſh parcels of clean water, and the ſeveral liquors allowed to ſettle. The water being then poured off, the pearly matter remains at the bottom of the conſiſtence of oil, called by the French *eſſence d'orient.* A little of this is dropped into a hollow bead of blueiſh glaſs, and ſhaken about ſo as to line the internal ſurface; after which, the cavity is filled with wax to give ſolidity and weight.

I do not know of any modern analyſis of pearls. Neumann found, that neither water nor ardent ſpirit acts upon its powder. The mineral acids diſſolve it, and from the vitriolic acid there ſeparates a cryſtalline matter. Cauſtic alkali, whether volatile or fixed, did not act upon it; but, which is ſtrange, the plain alkaline ley, or, as I take it, ſolution of mild alkali, corroded a little of the pearl into a flaky ſubſtance. Four drams of pearl diſtilled in a glaſs retort with an open fire gradually increaſed, gave over 14 grains of an empyreumatic alkaline fluid, with ſome veſtiges of empyreumatic oil in the neck of the retort. The fixed reſidue was of an aſh gray colour, and weighed three drams two ſcruples ſix grains. This being farther calcined in an open veſſel, then elixated with water, filtred, and evaporated, afforded five grains of a fixed ſalt, which appeared of a fine white colour, had a warm and not very ſaline taſte, efferveſced with vitriolic acid, and during the efferveſcence diſcharged a little marine acid in vapour.

From theſe experiments, I conclude, that the pearl conſiſts of much phoſphorated lime, of which the phoſphoric acid was diſengaged by the treatment with vitriolic acid, and the lime formed ſelenite; ſome animal mucilage, which afforded the volatile alkali and oil in diſtillation; and a ſmall portion of ſoda and marine ſalt found in the reſidue.

PEAT. Geanthrax. Kirwan remarks, that there are two ſubſtances called by this name. The firſt is of a brown, yellowiſh-brown, or black colour, found in mooriſh grounds in Scotland, Holland, Germany, and elſewhere. When newly cut it has a viſcid conſiſtence, but hardens by expoſure to the air. It conſiſts of clay mixed with calcareous earth and pyrites, and ſometimes contains common ſalt. While ſoft it is formed into oblong pieces for fuel, after ſeparation of the pyrites and ſtones. By diſtillation it affords water and oil, and volatile alkali, and a ſmall proportion of fixed alkali is found in its aſhes, which are either white or red according as they contain more or leſs ochre or pyrites.

The ſecond kind is found near Newbury in Berkſhire. It contains but little earth, but chiefly conſiſts of wood, branches, twigs, roots of trees, with leaves, graſs, ſtraw, and weeds.

The ſubſtance called ſtone turf in England, appears to be of the nature of peat. It is ſoft in the earth, but ſoon afterwards hardens. From long expoſure to the air it becomes pulverulent. Magellan informs us, that this pit turf is advantageouſly uſed by Mr. Wilkinſon, in his large ſmelting furnace for iron in Lancaſhire.

PECH BLENDE, or PITCH BLENDE. The celebrated profeſſor Klaproth has detected a new metallic ſubſtance in the mineral uſually diſtinguiſhed by the name of pech-blende, or pitch-blende, and ranged among the ores of zinc. As it is not reducible but with the moſt extreme difficulty, and then only into minute grains, it appears of little conſequence to enter into any formal deſcription of its metallic ſtate: for which reaſon, I ſhall here follow the order of the profeſſor's analyſis*.

The pitch-blende, or ore of uranite, is found in maſſes, or elſe ſtratified with other earths or minerals, in the Swediſh and Saxon mines. It conſiſts of two varieties: the firſt in maſſes of a blackiſh colour, inclining to a deep ſteel gray, of little brilliancy; its fracture is unequal, and concave in the ſmalleſt parts. It is perfectly opake, conſiderably hard, and becomes convertible into a black powder by trituration. Its mean ſpecific gravity is about 7.5. The ſecond variety is uſually found in ſtrata, and is diſtinguiſhed from the former by a deeper black colour intermixed with ſpots of red; its colour is more ſhining, and approaches that of coal; it is leſs hard, and, when pulverized, it has a greeniſh tinge.

This mineral ſuffers no change before the blow-pipe. With mineral alkali it affords a ſpongy, ſemi-opake, gray globule. With microcoſmic ſalt it melts, and affords a green tranſparent globule; and in both there are ſometimes ſeen ſmall globules of reduced lead. When the mineral is treated alone, in a proper veſſel, it gives out ſulphureous acid and ſulphur, with loſs of weight; but if it be afterwards kept ignited for a conſiderable time beneath a muffle, it gains ſome weight by calcination.

The vitriolic acid acts very imperfectly upon pitch-blende; but nitrous acid completely decompoſes it, holding moſt part in ſolution, while a ſmall proportion of ſulphur, and ſome ſiliceous earth, fall down. Marine acid acts but imperfectly upon it; but aqua regia diſſolves it, as well as the pure nitrous acid. This ſolution, after it had depoſited a ſmall quantity of corneous lead, afforded large tranſparent cryſtals by repoſe in the cold, which were of a faint yellowiſh-green colour, and of a figure not eaſy to be aſcertained.

It was remarkable, that this ſubſtance was not precipitable from its ſolvents either by iron or zinc; but volatile liver of ſulphur threw down a browniſh-yellow precipitate. Nut-galls did not precipitate any thing, unleſs the ſuperabundant acid were neutralized by an alkali; and in this caſe, the precipitate by galls was of a chocolate brown.

A diſtinctive criterion of this metallic ſubſtance was, its browniſh-red colour when ſeparated by Pruſſian alkali; a circumſtance indeed common alſo to copper: but this laſt metal falls down in flocks, whereas the former is uniformly ſeparated through the whole fluid. Volatile alkali uſually precipitates it of a yellow colour, more or leſs obſcure, according to the purity of the mineral, or of the alkali. The two fixed alkalis, when pure, precipitate it completely in the form of a lemon-coloured calx. Mild alkalis afford a paler calx.

The yellow precipitate is very ſoluble in acids, and affords cryſtals by combination with the vitriolic and acetous acids. Phoſphoric acid affords yellowiſh irregular flocks, ſparingly ſoluble in water. Alkalis do not diſſolve the yellow matter either in the dry or humid way.

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* Journal de Phyſique, April 1790.

Various attempts were made by the diſcoverer to revive it to the reguline ſtate. He triturated it with linſeed oil to the conſiſtence of a paſte, burned the oil in a roaſting teſt, then placed the remaining black powder in a crucible lined with charcoal, and well covered, and expoſed it to a violent heat; which operated a reduction of mangancſe in another crucible, but produced no other change in the calx of uranite than to render it ſoluble in nitrous acid, with effervescence, heat, and eſcape of nitrous air. This altered calx was then put into an aſſayer's teſt, covered with borax, and mixed with charcoal, and the lid luted on. The heat of a porcelain furnace reduced it into a coherent maſs, conſiſting of very ſmall metallic globules agglutinated together.

PELICAN. A pelican is a glaſs alembic conſiſting of one piece. It has a tubulated capital, from which two oppoſite and crooked beaks paſs out, and enter again at the belly of the cucurbit. This veſſel has been contrived for a continued diſtillation and cohobation, which chemiſts call circulation. The volatile parts of ſubſtances put into this veſſel riſe into the capital, and are obliged to return through the crooked beaks into the cucurbit; and this without interruption, or luting or unluting the veſſels.

Although the pelican ſeems to be a very convenient inſtrument, it is nevertheleſs little uſed, and even much neglected at preſent, either becauſe the modern chemiſts have not ſo much patience as the ancient chemiſts had, for making long experiments; or becauſe they find that two matraſſes, the mouth of one of which is inſerted into the mouth of the other, produce the ſame effect.

PELLICLE. By this word chemiſts mean a very thin ſaline cruſt, which is formed upon the ſurfaces of ſolutions of ſalts, when they are evaporated to a certain degree. This pellicle is nothing elſe than a number of ſaline particles cryſtallized by evaporation at the ſurface of the liquor, rather than any where elſe, becauſe the evaporation is made there. Theſe ſmall cryſtals of ſalt at firſt cover the ſurface of the liquor, and give it a duſky appearance, as if it were covered with duſt, or with a very thin ſkin, from which appearance the name of pellicle has been given.

As all cryſtallizable ſalts may be cryſtallized by evaporation alone, in the ſolution, therefore, of any of theſe ſalts a pellicle may be formed; and alſo, as all ſolutions of ſalts, evaporated till a pellicle is formed, furniſh cryſtals by expoſing the liquor to cold, chemiſts have eſtabliſhed a general rule for cryſtallization, to evaporate ſolutions of ſalts till a pellicle is formed, and then to leave them to cryſtallize by expoſure to cold.

This rule is applicable to many ſalts, but is not general; for ſome ſalts, as common ſalt, do not cryſtallize by expoſure to cold, although the ſolution of them has been previouſly evaporated till a pellicle has been formed: while other ſalts, as nitre and Glauber's ſalt, may be cryſtallized in great quantities, although their ſolutions have not been evaporated ſo much as that a pellicle has been formed. Hence, to cryſtallize ſuch ſalts as common ſalt, the evaporation muſt be continued after the pellicle has been formed; and to obtain fine cryſtals of nitre, Glauber's ſalt, and others which cryſtallize in a ſimilar manner, the evaporation muſt not be continued till a pellicle is formed, but their ſolutions muſt be left to cool ſlowly before it has been ſo much evaporated. See CRYSTALLIZATION.

PENNY-WEIGHTS, are fictitious parts into which we ſuppoſe any maſs of ſilver to be divided, to ſpecify its degree of purity.

Any maſs of ſilver, the purity of which is to be examined, is ſuppoſed to conſiſt of twelve equal parts called penny-weights; and if the ſilver be perfectly fine, and contain no allay, then the twelve parts of the maſs are all of pure ſilver, and this ſilver is ſaid to be ſilver of twelve penny-weights. If the maſs of ſilver contain a twelfth part of allay, it will then contain only eleven parts of pure ſilver, and it will be called ſilver of eleven penny-weights.

To expreſs more preciſely the value of ſilver, each penny-weight is ſubdivided into twenty-four grains.

A penny-weight in England is alſo a real weight uſed in the weighing of metals. It is equal to twenty-four real grains, and is the twentieth part of an ounce troy.

PEPPER. The black pepper of the Eaſt-Indies contains an eſſential oil, which has a ſtrong and durable ſmell, and a taſte the mildeſt of all eſſential oils. This oil is partly elevated in diſtillation by rectified ſpirit of wine, which thereby acquires the flavour but none of the pungency of the pepper. The ſpirituous extract is exceſſively fiery. The watery extract is alſo very hot and biting. Neither this menſtruum nor the ſpirit can, ſingly, extract all the hot matter of the pepper.

Sixteen ounces of black pepper yielded with water ten ounces of gummy extract, and afterwards with rectified ſpirit three drams of reſin; another pound, treated firſt with ſpirit, gave two ounces and two drams of reſinous extract; afterwards with water, ſeven ounces four drams and two ſcruples of gummy matter. This laſt extract had ſtill ſome degree of pungency, rectified ſpirit ſeeming not to take up all the active parts any more than water. Of eſſential oil, about two drams and a half may be obtained from a pound.

White pepper has the ſame kind of taſte and flavour as the black, but in a much leſs degree. It agrees alſo with the black in the nature of its chemical principles; and is, in effect, the ſame kind of fruit, gathered before it is grown fully ripe, and freed from the outer ſkin. Neumann.

PEPPER (JAMAICA), PIMENTO, OR ALL-SPICE. The pimento trees grow ſpontaneouſly, and in great abundance, in many parts of Jamaica, but more particularly on hilly ſituations near the ſea, on the northern ſide of that iſland.

This tree is ſo entirely the child of nature, that not one attempt in fifty to propagate the young plants, or to raiſe them from the ſeeds, in parts of the country where it is not found growing ſpontaneouſly, have ſucceeded. The uſual method of forming a new pimento plantation, which in Jamaica is called a walk, conſiſts in appropriating a piece of wood land, in the neighbourhood of a plantation already exiſting, or in a country where the ſcattered trees are found in a native ſtate, the woods of which being fallen, the trees are ſuffered to remain on the ground till they become rotten and periſh. In about a year after the firſt ſeaſon, abundance of young pimento plants will be found growing vigorouſly in all parts of the land, which are doubtleſs produced from ripe berries ſcattered there by the birds. At the end of two years it will be proper to cleanſe the land thoroughly, leaving ſuch only of the pimento trees as have a good appearance. Theſe will then ſoon form groves, which perhaps do not require much attention after the firſt four or five years.

It does not appear that in all the vegetable creation there is a tree of greater beauty than a young pimento. The trunk, which is of a gray colour, ſmooth and ſhining, and entirely free from bark, riſes to the height of fifteen or twenty feet. It then branches out on all ſides, richly clothed with leaves of a deep green, which, in the months of July and Auguſt, are beautifully relieved by an exuberance of white flowers. Theſe leaves are equally fragrant with the fruit; and, in diſtillation, yield an odoriferous oil, which, Edwards informs us, is very commonly uſed in the medicinal diſpenſaries of Europe for oil of cloves.

The berries become fit for gathering ſoon after the trees are in bloſſom; for the fruit is not ſuffered to ripen on the tree, becauſe the pulp in that ſtate is difficult to cure. It is, however, impoſſible to prevent ſome of the ripe berries from mixing with the reſt; but if the proportion of them be great, the price of the commodity is conſiderably injured.

It is gathered by the hand; and one labourer, on the tree, employed in gathering the ſmall branches, will give employment to three below (who are generally women and children) in picking the berries. An induſtrious picker likewiſe will fill a bag of 70lb. in the day. It is then ſpread on a terrace, and expoſed to the ſun for about ſeven days; in the courſe of which it loſes its green colour, and becomes of a reddiſh brown, and when perfectly dry it is fit for market.

In a favourable ſeaſon, a ſingle pimento tree has been known to yield 150lbs. of the raw fruit, or one cwt. of the dried ſpice: for there is generally a loſs of one-third in curing. A plenteous crop, however, occurs perhaps but once in five years; and the price in the Britiſh market fluctuates accordingly. Its average for ſome years paſt may be put at 10d. the pound, including the duty, which is 3d.

This, though certainly a much greater price than the commodity bore in former years, gives ſo little profit to the owner, compared with that of ſome other productions, that the growth of pimento decreaſes every year, many beautiful walks being daily cut down, and the land appropriated to the cultivation of ſugar. Its annual export from Jamaica (the only one of the Britiſh colonies that produces pimento) is about 6000 bags of 112lbs. each.

Neumann ſays, that pimento appears from a chemical examination to contain: 1. An indiſſoluble earth, exceeding in quantity all the other principles taken together, and amounting to five drams and a ſcruple in an ounce. 2. Gummy or mucilaginous matter, which is the ingredient next in quantity. An ounce treated with water at firſt gave two drams and two grains of gummy extract; and another ounce, freed by rectified ſpirit from all that the menſtruum could diſſolve, yielded ſtill with water five ſcruples of mucilage. 3. A reſinous ſubſtance in ſmaller quantity. The reſinous extract obtained by applying rectified ſpirit at firſt, amounted to only one dram and ſix grains from an ounce; an ounce freed from its mucilaginous matter by coction in water, yielded of pure reſin no more than one ſcruple. 4. An eſſential oil in ſtill ſmaller quantity: of this principle an ounce of pepper contains ſcarcely half a dram.

Upon examining the qualities of the ſeveral products, it appeared, that the oil is the principal and characteriſtic part, containing all the ſmell and the aromatic flavour, though not the pungency of the berry. As the prevailing flavour of pimento approaches that of cloves, the oil alſo greatly reſembles the genuine oil of cloves. It has the ſame kind of ſmell and taſte, diſcovers no great heat or pungency, and is ſo heavy as to ſink in water; to which may be added, that the oil of pimento, like that of cloves, reſides chiefly in the ſhell, or cortical part, the internal ſubſtance yielding little or none. 2. That the heat and pungency are lodged in the reſin. In this reſpect alſo pimento agrees with cloves; but as pimento in ſubſtance is far leſs hot and fiery than cloves, its reſin is alſo more mild. 3. That the gummy parts have very little activity.

Rectified ſpirit of wine elevates nothing from this ſpice in diſtillation, the oil of pimento being too ponderous to riſe with ſo light a fluid. The only way of making a ſpirit from it is to diſſolve ſome of the oil in pure ſpirit of wine. An agreeable ſpirituous water may be made with proof ſpirit, the watery phlegm in that liquor carrying up a part of the oil.

PERIDOT. The CHRYSOLITE, which ſee.

PERIGORD STONE. An ore of manganeſe, black, heavy, of a glittering appearance when broke, and in the whole reſembling a flag from a ſmith's forge.

PERUVIAN BARK. The cinchona officinalis Lin. which furniſhes this bark, is generally about fifteen feet high and ſix inches thick, ſomewhat reſembles our cherry-tree, grows promiſcuouſly in foreſts, particularly in the hilly parts of Quito in Peru, and is ſpontaneouſly propagated from its ſeeds.

The bark has ſome odour, to moſt people not unpleaſant; and very perceptible in the diſtilled water, in which floating globules, like eſſential oil, have been obſerved. Its taſte is bitter and aſtringent, accompanied with a degree of pungency, and leaving a conſiderable laſting impreſſion on the tongue.

Two ſpecies are mentioned, viz. the coloured and the white. The coloured includes the pale, the red, the yellow, and the knotty; their bark being coloured, having the cinchona taſte and ſmell, and the trees having very ſmooth leaves and purpliſh flowers. The white includes four varieties, their bark being of a whitiſh colour, with very little taſte or ſmell: the trees have broad hairy leaves, and very fragrant flowers with hairs on the inſide.

The proper red bark and one of the white kind have been found in the province of Santa Fé.

The cinchona Caribbæa Lin. cinchona Jamaicenſis, Phil. Tranſ. vol. lxxvii. p. 11. is called the ſea-ſide beech in Jamaica, and grows from 20 to 40 feet high. The white, furrowed, thick outer bark is not uſed; the dark-brown inner bark has the common flavour, with a mixed kind of taſte, at firſt of horſe-radiſh and ginger, becoming at laſt bitter and aſtringent. It ſeems to give more extractive matter than the cinchona officinalis. Some of it was imported from St. Lucia, in conſequence of its having been uſed with advantage in the army and navy during the laſt war. The freſh bark is found to be conſiderably emetic and cathartic, which properties it is ſaid to loſe on drying.

The pale and the red are chiefly in uſe. The pale is brought to us in pieces of different ſizes, either flat or quilled, and the powder is rather paler than that of cinnamon. The red is generally in much larger, thicker, flattiſh pieces, but ſometimes alſo in form of quills, and its powder is reddiſh, like that of Armenian bole. It is much more reſinous, and poſſeſſes the ſenſible qualities of the cinchona in a much higher degree than the other ſorts; and the more nearly theſe reſemble the red bark, the better they are now conſidered. The red bark is heavy, firm, ſound, and dry; friable betwixt the teeth; does not ſeparate into fibres, and breaks, not ſhivery, but ſhort, cloſe, and ſmooth. It has three layers: the outer is thin, rugged, of a reddiſh-brown colour, but frequently covered with moſſy matter: the middle is thicker, more compact, darker coloured, very reſinous, brittle, and yields firſt to the peſtle: the inmoſt is more woody, fibrous, and of a brighter red.

The

The Peruvian bark yields its virtues both to cold and boiling water; but the decoction is thicker, gives out its taſte more readily, and forms an ink with a chalybeate more ſuddenly than the freſh cold infuſion. This infuſion however contains at leaſt as much extractive matter, but more in a ſtate of ſolution; and its colour, on ſtanding ſome time with the chalybeate, becomes darker, while that of the decoction becomes more faint. When they are of a certain age, the addition of a chalybeate renders them green; and when this is the caſe, they are found to be in a ſtate of fermentation, and effete. Mild or cauſtic alkalis or lime precipitate the extractive matter, which in the caſe of the cauſtic alkali is re-diſſolved by a farther addition of the alkali. Lime-water precipitates leſs from a freſh infuſion than from a freſh decoction; and in the precipitate of this laſt, ſome mild earth is perceptible. The infuſion is by age reduced to the ſame ſtate with the freſh decoction; and then they depoſit nearly an equal quantity of mild earth and extractive matter; ſo that lime-water, as well as a chalybeate, may be uſed as a teſt of the relative ſtrength and periſhable nature of the different preparations, and of different barks. Accordingly cold infuſions are found by experiments to be leſs periſhable than decoctions; infuſions and decoctions of the red bark, than thoſe of the pale; thoſe of the red bark, however, are found by length of time to ſeparate more mild earth with the lime-water, and more extracted matter. Lime-water, as precipitating the extracted matter, appears an equally improper and diſagreeable menſtruum.

PETRIFACTIONS. Stony matters depoſited either in the way of incruſtation, or within the cavities of organized ſubſtances, are called petrifactions. Calcareous earth being univerſally diffuſed and capable of ſolution in water, either alone, or by the medium of fixed air or vitriolic acid, which are likewiſe very abundant, is depoſited whenever the water or the acid becomes diſſipated. In this way we have incruſtations of lime-ſtone or of ſelenite in the form of ſtalactites or drop-ſtones from the roofs of caverns and in various other ſituations. This ſimple principle of chemical depoſition, operating under different circumſtances, will account for a great number of ſtriking appearances obſerved in the bowels of the earth. In our ſmall and haſty experiments, a ſpeedy and copious ſolution of matter is required, and we do not ſcruple to declare that ſubſtance inſoluble which requires one or two thouſand times its weight of a fluid to diſſolve and ſuſpend it. But in the extenſive and long continued operations of nature, a much leſs ſolubility will be ſufficient to produce very marked effects. Hence, we may without difficulty account for the ſiliceous ſtalactites, mentioned by Chaptal, as well as the cryſtalliſed depoſitions of metallic bodies by us taken to be inſoluble.

Syſtematical writers more particularly confine the term petrifaction to ſuch organic ſubſtances as have been converted into ſtone, or have aſſumed the nature of a foſſil. Much labour and erudition have been employed in giving denominations from the Greek to theſe, according to their apparent origin. It is perhaps difficult to ſhew the utility of ſuch extended catalogues. At all events leſs will ſuffice the chemiſt.

The moſt remarkable obſervations relative to petrifactions are thus given by Kirwan:

1ſt. That thoſe of ſhells are found on or near the ſurface of the earth; thoſe of fiſh deeper, and thoſe of wood deepeſt. Shells in ſpecie are found in immenſe quantities at conſiderable depths.

2dly. That thoſe organic ſubſtances that reſiſt putrefaction moſt, are frequently found petrified: ſuch as ſhells and the harder ſpecies of woods; on the contrary, thoſe that are apteſt to putrefy are rarely found petrified, as fiſh, and the ſofter parts of animals, &c.

3dly. That they are moſt commonly found in ſtrata of marl, chalk, lime-ſtone, or clay, ſeldom in ſand-ſtone, ſtill more rarely in gypſum, but never in gneiſs, granite, baſaltes, or ſhoerl; but they ſometimes occur among pyrites, and ores of iron, copper, and ſilver, and almoſt always conſiſt of that ſpecies of earth, ſtone, or other mineral that ſurrounds them, ſometimes of ſilex, agate, or carnelian.

4thly. That they are found in climates where their originals could not have exiſted.

5thly. That thoſe found in ſlate or clay are compreſſed and flattened.

The arrangement of petrifactions by Cronſtedt is made under four heads, earthy, ſaline, inflammable, and metallic.

Calcareous petrifactions are: 1. Chalk in the form of vegetables or animals, either looſe or friable, or 2. Filled with ſolid lime-ſtone.

Siliceous petrifactions are of the nature of flint or agate. Carnelians have been found in the form of ſhells, at the river Tomm in Siberia; agate in the form of wood; corraloids (millepora) of white flint; and wood of yellow flint.

This laſt is the produce of Italy, Adrianople, and Loughneagh a lake in Ireland. It is uſed to ſharpen razors.

Argillaceous petrifactions have been obſerved in the form of the roots of trees. The oſteocolla is of this kind.

Saline petrifactions are extraneous bodies penetrated by mineral ſalts. Human bodies have been twice found in the mine at Falun in Dalerne. The laſt was kept ſeveral years in a glaſs caſe, but began at length to moulder and fall to pieces. The turf and roots of trees, which are found in water ſtrongly impregnated with vitriol, are conſiderably changed in their nature. They do not burn with a flame, but only like a coal in a ſtrong fire, neither do they decay in the air.

Extraneous bodies penetrated by mineral inflammable matter appear to be of the nature of pit-coal. Of this kind is jet. See that article. Vegetables are found penetrated with aſphaltum in a ſtate of leſs preſervation than jet. The compound of ſulphur and iron, or martial pyrites, is likewiſe the agent of petrifactions. Of theſe Cronſtedt mentions human, bivalves, univalves, and inſects, but gives no particulars of their hiſtory.

Metallic petrifactions are: 1. Of ſilver, either native on the ſurfaces of ſhells in England, or mineralized with copper and ſulphur in the fahlertz or gray ſilver ore, in form of ears of corn, &c. and ſuppoſed to be vegetables. Theſe are found in argillaceous ſlate at Frankenburg, and Tahlitteran in Heſſe. 2. Of copper, which is either in the form of calx, or mineralized. The calx of copper is depoſited in the parts of animals. The turquoiſe-ſtone, ſee page 560, is ſuppoſed to be ivory, or other bones of animals, which have undergone this change. Mineralized copper, or the cupreous pyrites, penetrates ſhells, and is alſo found in the form of fiſh in various parts of Germany.

The ferruginous petrifactions likewiſe conſiſt of iron, either in the form of a calx, which has aſſumed the place or ſhape of extraneous bodies (this conſiſts chiefly of vegetables in the form of ochre or hematites); or elſe the martial pyrites, which has operated as the agent of petrifaction.

PETROLEUM. Petrol, Bergoel, Steinoel. Doctor Prieſtley has ſhewn in the third volume of his Obſervations and Experiments on Air, that eſſential oils, long expoſed to the atmoſphere, abſorb not only the pure part, but alſo the phlogiſticated part of it; an abſorption, which muſt in time produce conſiderable changes in them. By a proceſs of this ſort naphtha is converted into petrol, which is an oil of various degrees of denſity, according to the time during which it has been expoſed to the atmoſphere; its colour is reddiſh, or yellow, brown, greeniſh, or blackiſh; it is found trickling from rocks, or iſſuing from the earth in the Duchy of Modena, and in various parts of France, Swiſſerland, Germany, and Scotland, as well as in Aſia; alſo on the ſurface of the water of different fountains, or mixed with earth or ſand, from which it is ſeparated by infuſion in water; the thinneſt ſort poſſeſſes the properties of naphtha, though in a leſſer degree. It is rendered finer by diſtillation with water, and leaves a reſinous reſiduum, and if diſtilled with a volatile alkali, the alkali acquires the properties of ſuccinated ammoniac: and hence contains the acid of amber. Some ſorts of it, according to Monnet, are nearly of the denſity of nut oil. It is inſoluble in ſpirit of wine. Kirwan.

Mr. Fabroni of Florence has diſcovered that petroleum rectified ſeveral times is a good ſolvent of the elaſtic reſin, and does not at all change its properties.

PETUNTSE. See PORCELAIN, alſo KAOLIN.

PEWTER, which is commonly called étain in France, and generally confounded there with true tin, is a compound metal, whoſe baſis is tin. The beſt ſort conſiſts of tin allayed with about a twentieth, or leſs, of copper or other metallic bodies, as the experience of the workmen has ſhewn to be the moſt conducive to the improvement of its hardneſs and colour, ſuch as lead, zinc, biſmuth, and the metallic or reguline part of antimony. There are three ſorts of pewter, diſtinguiſhed by the names of plate, trifle, and ley-pewter. The firſt is uſed for plates and diſhes; the ſecond for the pints, quarts, and other meaſures of beer; and the ley-pewter is uſed for wine meaſures and large veſſels.

The beſt ſort of pewter conſiſts of 17 parts of regulus of antimony to 100 parts of tin; but the French add a little copper to this kind of tin. A very fine ſilver-looking metal is compoſed of 100 pounds of tin, eight of regulus of antimony, one of biſmuth, and four of copper. On the contrary, the ley-pewter, by comparing its ſpecific gravity with thoſe of the mixtures of tin and lead, muſt contain more than a fifth part of its weight of lead. This quantity of lead is far too much, conſidering ſome of the uſes this ſort of pewter is applied to; for acid wines will readily corrode the lead of the flagons, in which they are meaſured, into ſugar of lead; which being taken internally, is productive of various chronic diſeaſes, as the colica pictonum, palſies, ſtupors in the limbs, &c.

Foreigners generally aſſert, that Engliſh tin is always a mixed metal when exported abroad: and the French encyclopediſts in particular (article ETAIN) inform us, on the authority of M. Rouelle, that the Engliſh tin, when caſt into moulds of ſix inches in thickneſs, and cooled, if it be divided into three layers, the uppermoſt has three pounds of copper on the 100 of tin: the ſecond layer has five pounds of lead to the ſame quantity of tin; and the loweſt layer has nine of lead to the 100 of tin. Geoffroy had formerly given a ſimilar account of the Engliſh tin, with ſome variety in the doſes. But there never was any other foundation for ſuch an aſſertion, than that pewter has been miſtaken for tin abroad: and in fact, all pewter diſhes, and all other pewter-pieces are called by the name of tin ware all over Europe, except in England. Nor could there ever be any advantageous motive to hinder the export of pure tin from England, where it is found in a greater abundance than any where elſe. Beſides the above, neither Borlaſe, nor Pryce, who wrote ſo minutely on the method of preparing tin in Cornwall, mentions any operation or mixtures this metal undergoes or receives, before or after it is caſt in the ſlabs, blocks, or pieces of tin, in which ſize and form it is ſold, and ſent to every market in Europe; ſo that the whole muſt be a miſtake in terms, as already mentioned, by taking pewter ſimply for tin.

PHLEGM. Chemiſts have given the name phlegm to the moſt watery part obtained from bodies by diſtillation or otherwiſe. It is now little uſed.

Phlegm is frequently water mixed ſuperabundantly, and not combined in the bodies from which it is obtained. Such are the phlegms obtained by diſtillation with the heat of a water-bath, from all thoſe vegetable and animal matters which contain no principle ſo volatile as to riſe with a leſs heat than that of boiling water. Theſe phlegms, which are produced merely by drying, are nothing but water almoſt pure, that is, the water of vegetation: but a phlegm conſiſting of water which had been combined in any body, as for inſtance, the phlegm obtained in the diſtillation of oils, is far from being pure water. It is ſtill mixed and even united with a ſenſible quantity of the principles of the body, and requires further operations, and chiefly the aſſiſtance of intermediate ſubſtances, to ſeparate it perfectly.

Neither is that phlegm pure water, which, though it is ſuperabundant, yet adheres to certain ſubſtances, eſpecially to thoſe that are volatile. Such are liquid volatile alkalis, and moſt alkalis. By diſtillation we may ſeparate a conſiderable quantity of their phlegm or ſuperabundant water, which operation is called dephlegmation: but this phlegm contains always a certain quantity of the ſaline matters with which it was originally mixed.

Hence we may ſee that the word phlegm ſignifies in general the moſt watery part ſeparated from ſeveral bodies, but that is rarely pure water; and that phlegms differ from each other according to the nature of the ſubſtances from which they are obtained.

PHLOGISTON. The whole of phyſical ſcience conſiſts in the arrangement or claſſification of facts. Inveſtigation or analyſis in chemiſtry is employed merely in diſcovering general reſults under which particular facts may be arranged, or to which they may be referred, notwithſtanding the obſcurity or diſguiſe produced by individual circumſtances, not eſſential to the phenomenon under inveſtigation. Thus we may remark in the conſiderably ſimple motions of the heavenly bodies, that the moon revolves round the earth; but the ſituation of our planet renders the revolutions of the other planets round the ſun leſs obvious. Inveſtigation from optical principles, however, proved this to be the caſe, and it became a conſiderable advance in aſtronomy, that the motions of all the planets could be arranged under the fact of the moon's revolution conſidered as a general reſult. In this ſtate of knowledge it became an object of reſearch to aſcertain what general fact theſe motions might be referred to. Des Cartes referred them to the motion of a floating body carried round by a vortex or whirling current of water. It was afterwards aſcertained from the more general facts of bodies in motion, that the revolutions of the planets and thoſe of floating bodies are by no means of the ſame kind. Newton * was accidentally led to conſider the path of bodies projected near the ſurface of the earth; and he found by accurate examination, that

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* See Voltaire's Elements of the Newtonian Philoſophy.

the moon is a projectile kept from falling by a force impreſſed on it, in the ſame manner as a ſtone is made to deſcribe a curve through the air, which laſt only wants a ſufficient impulſe to carry it round the earth in an orbit. Here then we ſee a general fact of another and more remote kind. Copernicus generalized the celeſtial motions, by merely referring them to the moon's motion. Newton generalized them ſtill more, by referring this laſt to the motion of a ſtone through the air. And yet farther, this motion of the ſtone was ſhewn to be referable to two ſimple facts, namely, the uniform motion of a body acted on by a paſt impulſe, and the accelerated motion of a body conſtantly acted upon by gravitation, or the cauſe of weight. Thus far Aſtronomers have proceeded in this department of ſcience, and at this point they are at a ſtand; becauſe no facts more ſimple have yet been remarked, under which the communication of motion either by impulſe or gravitation can be claſſed.

From this familiar elucidation of the progreſs of aſtronomical ſcience, which is very ſimple, it may eaſily be ſeen how great the probability is, that error may ariſe from claſſing facts under others of a different nature, and that when a combination of truth and falſehood is exhibited, as the means of explaining natural phenomena, the former may be made to ſupport and maintain the latter, as was the caſe with the ſyſtem of Copernicus united with the vortices of Des Cartes. It may alſo be remarked, that the falſe reſults, which from time to time are incorporated with the materials of any branch of philoſophy, owe their eſtabliſhment to ſuperficial views, and the apparent or partial reſemblance which ſeduces the cultivators of infant ſcience: and that they generally maintain their ground until ſome very conſiderable addition is made to the general maſs of information.

Without pretending to enter the wide field of chemical hiſtory, we may in a few words obſerve, that, from the nature of things, the firſt chemical operations muſt have conſiſted in the effects of heat applied to bodies in the operations of cookery, of pottery, and of mine works, which accordingly have exiſted, at leaſt, as early as hiſtory itſelf. The operations in the humid way with ſaline ſubſtances appear to have been of much later date. And thoſe upon bodies in the aeriform ſtate are ſtill more modern. Theſe three claſſes of operations comprehend the whole of chemiſtry, and would naturally lead us to conſider the ſubject of phlogiſton, as it is ſuppoſed to exhibit itſelf in the dry, the humid, and the aeriform proceſſes: but theſe proceſſes are ſo frequently combined together, that it is ſcarcely poſſible to treat of them ſeparately.

When bodies are heated to ſuch a degree as to emit light, there are ſome which if left to themſelves in the open air become cold again without any perceptible change in their properties; and there are others which retain their ignition, and even become hotter until an entire decompoſition of the whole ſubſtance has taken place. This proceſs is well known by the name of combuſtion or burning, and the diſtinction of bodies into combuſtible and incombuſtible is one of the moſt ſtriking and diſtinct of any we are acquainted with. That a combuſtible body muſt have ſomething in its properties or component parts not to be found in an incombuſtible body is evident. But it is not always eaſy to diſtinguiſh the exiſtence of a property from that of a component part. For any thing we know on this obſcure ſubject, two bodies may agree in certain properties and differ in others; whence it may follow, that bodies may agree in the property of combuſtibility, and yet poſſeſs no common principle or component part. It was nevertheleſs a habit of reaſoning, much indulged in the middle ages, to refer effects rather to diſtinct ſubſtances than to habitudes or properties. The ancient chemiſts did not therefore ſo much endeavour to explain combuſtibility as a property, as to aſcertain what might be the principle of combuſtibility in bodies. They looked round for general facts. Their attention became fixed on ſuch bodies as are the moſt eminently combuſtible. They ſuppoſed theſe bodies to exiſt in various proportions in other bodies capable of being burned. In this way the ſcience of chemiſtry came to be filled with accounts of the oils and ſulphurs of bodies. But as it was not found practicable to exhibit theſe oils or ſulphurs, a diſtinction was conſequently made between the groſs oils and ſulphurs, and the more ſubtle or philoſophical matters of the ſame denomination, which were ſuppoſed to give inflammability to bodies. As this refinement was carried farther, the denominations themſelves were diſmiſſed; and by the perſpicuous modifications of Becher and Stahl, a common principle of inflammability, identical, and always ſimilar to itſelf, capable of being extricated from bodies, and transferrable from one body to another in certain circumſtances, was univerſally admitted by chemiſts under the denomination of phlogiſton. The nature of the phlogiſton was to be inveſtigated from the facts. The moſt ſtriking fact is, that the temperature of bodies becomes raiſed in thoſe circumſtances where the phlogiſton is ſaid to be extricated. The phlogiſton was therefore conſidered to be elementary fire, exiſting as one of the principles of combuſtible bodies, deprived of its moſt eminent property while in this ſtate of combination, but exhibiting all its diſtinctive attributes at the inſtant of diſengagement.

The doctrine of heat, though of ſuch extenſive importance in almoſt every natural change, continued long in an unimproved ſtate, becauſe the facts are in general ſimple, and not eaſily analyſed and referred to facts ſtill ſimpler. Yet the moderns in their reflections on this ſubject could not but perceive that the temperature of bodies, and conſequently the matter of heat, if ſuch a thing exiſts, diſtributes itſelf with a ſort of equality, as well through incombuſtible as combuſtible bodies. While the various capacities of bodies were unknown, the diſpoſition of heat to enter into all bodies muſt have appeared to be abſolutely equal. It was not eaſy to reconcile this with Stahl's doctrine of phlogiſton or fixed fire. Again, this doctrine overlooks the neceſſity of reſpirable air in the proceſs of combuſtion. The modern chemiſts were obliged to make conſiderable alterations, and thoſe who maintained the phlogiſton are at preſent returned to the old doctrine of ſulphur and oils, though in more general terms. With them the phlogiſton is not fixed fire, but ſome identical ſubſtance, the property of which is to be combuſtible, viz. to unite with reſpirable air, when at a certain temperature, and to produce, extricate, or develop heat. But what this ſubſtance may be is matter of diſcuſſion. For a time it was ſuppoſed, according to the hypotheſis of Kirwan, to be inflammable air in a combined ſtate. But it has not been poſſible to extricate inflammable air from the metals, excepting when water was preſent, of which this air is taken to be a component part. This doctrine is little inſiſted upon at preſent, and as far as authority may be conſidered of any value, it is deſtitute; for Kirwan has abandoned the phlogiſton altogether.

Since the doctrine of phlogiſton is tacitly eſtabliſhed upon the poſition that a common principle of combuſtibility is neceſſary for the explanation of the facts; and as this poſition is aſſumed but not proved, we ſhall gain another different view of the ſubject by rejecting it, and ſubſtituting the property of rapidly combining with reſpirable air. This is ſimply the doctrine of the modern, or antiphlogiſtian chemiſts. There is no inconſiſtency in affirming, that bodies may be ſtrongly diſpoſed to inflammability, and yet differ in every other property. Let us then ſay, they reject as mere ſuppoſition, the notion that they do agree in any other reſpect than ſuch as may be indicated by poſitive facts. The facts of combuſtion are ſimply, that reſpirable air is abſorbed and enters into combination, while heat is given out. Elaſtic fluids are known to contain more heat in that ſtate than when condenſed. Much heat muſt therefore ariſe from the condenſation of the vital air. It does not neceſſarily follow, that any heat came from the combuſtible body, or at leaſt not more than might have been extricated under an equal change of circumſtances from an incombuſtible body. Whence it follows, that the ſimple explanation of combuſtion from the facts is, that the combuſtible body has a ſtrong attraction for vital air, at a certain temperature, that it has attracted this fluid, with the production of heat during the combination, and that its properties are changed. See HEAT.

In two theories, which differ ſo widely as that the one ſubtracts where the other adds, it muſt be a material, though not a deciſive, point to aſcertain whether the body under conſideration becomes heavier or lighter by being burned. In this reſpect the antiphlogiſtian theory has the advantage; for, in all experiments which have yet been accurately made, bodies gain weight by being burned. If the reſidues of combuſtion were in all caſes fixed, it would be eaſy to aſcertain this general fact. But in all organiſed ſubſtances, and many among thoſe of the mineral kingdom, moſt of the products aſſume the vaporous or elaſtic ſtate. When the vapour is condenſible, it is eaſier to aſcertain its weight than when it continues elaſtic. There are many difficulties, however, which attend the accurate accompliſhment of experiments, wherein a known ſupply of vital air is required to be given to the combuſtible matter, and the products are to be received, condenſed, meaſured, or weighed. A notion of theſe difficulties may be had by conſulting the writings of Lavoiſier *. This chemiſt found, by burning ardent ſpirit in a lamp with a ſerpentine chimney kept cool upon the principle of the worm of a ſtill, nearly 17 ounces of water were collected from 16 of the ſpirit, and it is known that a conſiderable product of fixed air muſt alſo have been loſt.

The metals which are truly combuſtible bodies, though few of them will burn in the common air of the atmoſphere, without the aſſiſtance of foreign heat, exhibit this increaſe of weight in a remarkable manner. The general facts are, as I find them ready enumerated by Fourcroy in his notes on Kirwan's phlogiſton, 1. There is no elaſtic fluid which is capable of calcining the metals but vital air. 2. They are not calcined by atmoſpheric air, but in proportion to the quantity of vital air it contains. 3. In proportion as they burn, they abſorb, condenſe, and fix this vital air, which proves, as he infers, that the latter abandons that which held it fuſed, or divided in the ſtate of an elaſtic fluid. 4. Hence he adds, that it is only the ſolid part of vital air which unites to metals. 5. And for this reaſon it is that rapid combuſtion is attended with a diſengagement of heat and light: 6. But as the heat and light are bodies of ſuch levity, that their weight cannot be appreciated by our inſtruments, the loſs and diſengagement of theſe, which he ſuppoſes to be principles, make no change in the weights of our experiments. 7. Metals therefore increaſe in weight by the quantity of vital air they fix during their combuſtion. 8. All the ſemi-metals, and imperfect metals, preſent abſolutely the ſame phenomena, and are therefore facts of the ſame kind. 9. In all the various proceſſes by which metals are calcined, otherwiſe than by

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* Elements of Chemiſtry. Memoirs of the Academy of Sciences. Journal de Phyſique.

means of the air, they undergo abſolutely the ſame modification, their weight increaſes, and they loſe their metallic ſtate in the ſame manner as by the ſimultaneous action of heat and the air. Mr. Fourcroy calls theſe poſitive and ſimple facts, though indeed they include the conſideration of the materiality of heat, which may perhaps be no more a ſeparate matter than the phlogiſton.

He afterwards adds the following obſervations: 1. That the metals differ in the ſeveral quantities of vital air they require for their ſaturation. 2. That ſome loſe this principle by the ſimple contact of heat and light, ſometimes even by the action of the latter only aſſiſted by very little heat. 3. That the greater number do not admit of this, and are not therefore reducible by theſe agents. 4. That no induction can be made from this difference in the metallic calces, any more than it could be fairly concluded that neutral vitriolic ſalts do not contain the ſame acid as the metallic vitriols, becauſe the latter are decompoſable by mere heat, and the former not. 5. That not only the vital air is abſorbed in different doſes, but that it is likewiſe combined in them, after privation of a greater or leſs quantity of the matter of heat, and of light; and that the capacities of the reſidues or calces for heat will differ accordingly. 6. That each metallic calx may exiſt in different ſtates of calcination from the abſorption of the ſmalleſt quantity poſſible of vital air unto that which is neceſſary for ſaturating the metal; ſo that the calcination of each metal ſtops, as it were, at different degrees. Thus it is that lead becomes calcined, firſt of a gray, and then of a yellow and red colour, and iron is black and brown. 7. That the periods of calcination in each metal depend on circumſtances which are more or leſs favourable to the attraction of the metals for vital air; the principal of which circumſtances is a certain temperature, neither too high nor too low. Thus a certain metal will abſorb and fix only a very ſmall quantity of the vital air of the atmoſphere, and never becomes any thing but a calx of a certain nature, at the uſual temperature, whereas it will fix a much greater quantity, and its calcination will become complete, if it be ſtrongly heated; ſuch are zinc, iron, &c. 8. That the different metallic ſubſtances differ in their attractions for the baſis of vital air, part of which attractions have been already aſcertained as to their order, by Bergman, who, according to the ſyſtem of phlogiſton, remarked that the precipitation of metals in acids by each other, follows the ſame order in all acids, and muſt therefore depend much more on their diſpoſition to become calcined, than on their reſpective attractions for the acid ſolvent. 9. Laſtly, the metallic calces are decompoſed and reduced to the metallic ſtate by the laws of attraction followed by the vital air. Thus heat ſeparates it from ſome, one metal takes it from another, inflammable air takes it from moſt metals, and carbone, or pure charcoal, perhaps from all.

Among the few metals which are capable of calcination and reduction by mere heat, there is no one which ſets the theory of that proceſs, and the doctrine of the antiphlogiſtians, in ſo clear a point of view as mercury. Lavoiſier gives a very perſpicuous account of the experiment *, which can only be performed on a ſmall ſcale.

He took a mattraſs of about 36 cubical inches capacity, having a long neck of ſix or ſeven lines internal diameter, which was bended firſt ſideways like that of a retort, and then in a reverſe direction upwards, ſo as conveniently to be inſerted beneath an inverted jar of mercury for pneumatic experiments. Into this mattraſs was introduced four ounces of mercury, and a portion of the air was

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* Elements of Chemiſtry. The remarks, as well as the account of the experiment, are Lavoiſier's.

then drawn out of the receiver by means of a ſyphon, and the ſtation of the mercury noted in this veſſel by paſting a ſlip of paper on its external ſurface. Having accurately noted the height of the thermometer and barometer, he lighted a fire in a furnace, which he kept up almoſt continually for twelve days, ſo as to keep the quickſilver always very near its boiling point. Nothing remarkable took place during the firſt day ; the mercury, though not boiling, was continually evaporating, and covered the interior ſurface of the veſſel with ſmall drops, at firſt very minute, which gradually augmenting to a ſufficient ſize, fell back into the maſs at the bottom of the veſſel. On the ſecond day ſmall red particles began to appear on the ſurface of the mercury: theſe, during the four or five following days, gradually increaſed in ſize and number, after which they ceaſed to increaſe in either reſpect. At the end of twelve days, ſeeing that the calcination of the mercury did not at all increaſe, he extinguiſhed the fire, and allowed the veſſels to cool. The bulk of air in the body and neck of the mattraſs, and in the bell-glaſs, reduced to a medium of 28 inches of the barometer, and 54.5° of the thermometer, at the commencement of the experiment was about 50 cubical inches. At the end of the experiment the remaining air reduced to the ſame medium, preſſure and temperature, was only between 42 and 43 cubical inches; conſequently it had loſt about one-ſixth of its bulk. Afterwards, having collected all the red particles, formed during the experiment, from the running mercury in which they floated, he found theſe to amount to 45 grains.

Mr. Lavoiſier was obliged to repeat this experiment ſeveral times, as it is difficult in one experiment both to preſerve the whole air upon which we operate, and to collect the whole of the red particles or calx of mercury, which is formed during the calcination.

The air which remained after the calcination of the mercury in this experiment, and which was reduced to five-ſixths of its former bulk, was no longer fit either for reſpiration or for combuſtion; animals being introduced into it were ſuffocated in a few ſeconds, and when a taper was plunged into it, it was extinguiſhed as if it had been immerſed in water.

In the next place, he took 45 grains of the red matter formed during this experiment, which he put into a ſmall glaſs retort, having a proper apparatus for receiving ſuch liquid, or gaſeous product, as might be extracted: having applied a fire to the retort in the furnace, he obſerved that in proportion as the red matter became heated, the intenſity of its colour augmented. When the retort was almoſt red-hot, the red matter began gradually to decreaſe in bulk, and in a few minutes after it diſappeared altogether; at the ſame time $41\frac{1}{2}$ grains of running mercury were collected in the recipient, and ſeven or eight cubical inches of elaſtic fluid, greatly more capable of ſupporting both reſpiration and combuſtion than atmoſpherical air, were collected in the pneumatic apparatus.

A part of this air being put into a glaſs tube of about an inch diameter, ſhewed the following properties: A taper burned in it with dazzling ſplendour, and charcoal inſtead of conſuming quickly, as it does in common air, burnt with a flame, and attended with a decrepitating noiſe, like phoſphorus, and threw out ſuch a brilliant light that the eyes could hardly endure it. This is the air to which Dr. Prieſtley gave the name of dephlogiſticated air. See AIR ATMOSPHERICAL, AIR VITAL.

In reflecting upon the circumſtances of this experiment we readily perceive, that the mercury, during its calcination, abſorbs the ſalubrious and reſpirable part of the air, or, to ſpeak more ſtrictly, the baſe of this reſpirable part; that the remaining part is a ſpecies of mephitis, incapable of ſupporting combuſtion or reſpiration; and conſequently that atmoſpheric air is compoſed of two elaſtic fluids of different and oppoſite qualities. As a proof of this important truth, if we recombine theſe two elaſtic fluids, which we have ſeparately obtained in the above experiment, viz. the 42 cubical inches of mephitis, with the eight cubical inches of reſpirable air, we reproduce an air preciſely ſimilar to that of the atmoſphere, and poſſeſſing nearly the ſame power of ſupporting combuſtion and reſpiration, and of contributing to the calcination of metals. See Iron.

Although this experiment furniſhes us with a very ſimple means of obtaining the two principal elaſtic fluids which compoſe our atmoſphere ſeparate from each other, yet it does not give us an exact idea of the proportion in which theſe two enter into its compoſition: for the attraction of mercury to the reſpirable part of the air, or rather to its baſe, is not ſufficiently ſtrong to overcome all the circumſtances which oppoſe this union. Theſe obſtacles are the mutual adheſion of the two conſtituent parts of the atmoſphere for each other, and the elective attraction which unites the baſe of vital air with caloric: in conſequence of theſe, when the calcination ends, or is at leaſt carried as far as is poſſible, in a determinate quantity of atmoſpheric air, there ſtill remains a portion of reſpirable air united to the mephitis, which the mercury cannot ſeparate. It is aſcertained from other experiments, that, at leaſt in our climate, the atmoſpheric air is compoſed of reſpirable and mephitic airs, in the proportion of 27 and 73.

Since, during the calcination of mercury, air is decompoſed, and the baſe of its reſpirable part is fixed and combined with the mercury, it follows from the general facts relating to combuſtion, that heat and light muſt be diſengaged during the proceſs. But the two following cauſes prevent us from being ſenſible of this taking place, as the calcination laſts during ſeveral days, the diſengagement of heat and light ſpread out in a conſiderable ſpace of time, becomes extremely ſmall for each particular moment of the time, ſo as not to be perceptible, and the operation being carried on by means of fire in a furnace, the heat produced by the calcination itſelf becomes confounded with that proceeding from the furnace. To this might be added, that reſpirable part of the air, or rather its baſe, in entering into combination with the mercury, does not part with all the heat which it contained, but ſtill retains a part of it in the new compound; but the diſcuſſion of this point, and its proofs from experiment, do not belong to this part of our ſubject.

The diſengagement of heat and light is rendered apparent to the ſenſes, when the decompoſition of air takes place in a more rapid manner; for this purpoſe iron is excellently adapted, as it poſſeſſes a much ſtronger affinity for the baſe of reſpirable air than mercury. The following elegant experiment of Dr. Ingenhouſz, upon the combuſtion of iron, is well known. Take a piece of fine iron wire, twiſted into a ſpiral; fix one of its extremities into a cork, adapted to the neck of a bottle, and fix to the other extremity of the wire a ſmall morſel of tinder. Matters being thus prepared, fill the bottle with air deprived of its mephitic part, then light the tinder, and introduce it quickly with the wire upon which it is fixed into the bottle, which you ſtop up with the cork. The inſtant the lighted tinder comes into contact with the vital air, it begins to burn with great intenſity; and, communicating the inflammation to the iron wire, it too takes fire, and burns rapidly, throwing out brilliant ſparks: theſe fall to the bottom of the veſſel in rounded globules, which become black in cooling, but retain a degree of metallic ſplendour. The iron thus burnt is more brittle even than glaſs, is eaſily reduced into powder, and is ſtill attractible by the magnet, though not ſo powerfully as it was before combuſtion.

Lavoiſier repeated this experiment with a view to aſcertain the products. Having filled a bell-glaſs of about ſix pints meaſure, with pure air, or the highly reſpirable part of air, he tranſported this jar by means of a very flat veſſel into a quickſilver bath, taking care to render the ſurface of the mercury perfectly dry, both within and without the jar, with blotting paper. He then provided a ſmall cup of china-ware, very flat and open, in which he placed ſome ſmall pieces of iron, turned ſpirally, and arranged in ſuch a way as ſeemed moſt favourable for the combuſtion being communicated to every part. To the end of one of theſe pieces of iron was fixed a ſmall piece of tinder, to which was added about the ſixteenth part of a grain of phoſphorus; and, by raiſing the bell-glaſs a little, the china-cup with its contents was introduced into the pure air. It is true that by this means ſome common air muſt mix with the pure air in the glaſs; but this, when it is done dextrouſly, ſays Mr. Lavoiſier, is ſo very trifling, as not to injure the ſucceſs of the experiment. This being done, a part of the air was ſucked out from the bell-glaſs, by means of a ſyphon, ſo as to raiſe the mercury within the glaſs; and to prevent the mercury from getting into the ſyphon, a ſmall piece of paper was twiſted round its extremity. In ſucking out the air, if the motion of the lungs only be uſed, we cannot make the mercury riſe above an inch or an inch and a half: but, by properly uſing the muſcles of the mouth, we can, without difficulty, cauſe it to riſe ſix or ſeven inches.

He then took an iron wire, properly bent for the purpoſe, and making it red-hot in the fire, preſſed it through the mercury into the receiver, and brought it in contact with the ſmall piece of phoſphorus attached to the tinder. The phoſphorus inſtantly took fire, which communicated to the tinder, and from that to the iron. When the pieces have been properly arranged; the whole iron burns, even to the laſt particle, throwing out a white brilliant light, ſimilar to that of Chineſe fire-works. The great heat produced by this combuſtion melts the iron into round globules of different ſizes, moſt of which fall into the china-cup; but ſome are thrown out of it, and ſwim on the ſurface of the mercury. At the beginning of the combuſtion, there is a ſlight augmentation in the volume of the air in the bell-glaſs, from the dilatation cauſed by the heat; but preſently afterwards a rapid diminution of the air takes place, and the mercury riſes in the glaſs, inſomuch that when the quantity of iron is ſufficient, and the air operated upon is very pure, almoſt the whole air employed is abſorbed.

It is proper to remark in this place, that, unleſs in making experiments for the purpoſe of diſcovery, it is better to be contented with burning a moderate quantity of iron; for when this experiment is puſhed too far, ſo as to abſorb much of the air, the cup which floats upon the quickſilver approaches too near the upper part of the bell-glaſs; and the great heat produced, which is followed by a very ſudden cooling, occaſioned by the contact of the cold mercury, is apt to break the glaſs, in which caſe the ſudden fall of the column of mercury, which happens the moment the leaſt flaw is produced in the glaſs, cauſes ſuch a wave, as throws a great part of the quickſilver from the baſon. To avoid this inconvenience, and to inſure ſucceſs to the experiment, one dram and a half of iron is ſufficient to burn in a bell-glaſs, which holds about eight pints of air. The glaſs ought likewiſe to be ſtrong, that it may be able to bear the weight of the column of mercury which it has to ſupport.

By this experiment it is not poſſible to determine at one time, both the additional weight acquired by the iron and the changes which have taken place in the air. If it is wiſhed to aſcertain what additional weight has been gained by the iron, and the proportion between that and the air abſorbed, we muſt carefully mark upon the bell-glaſs, with a diamond, the height of the mercury, both before and after the experiment. After this, the ſyphon, guarded as before with a bit of paper to prevent its filling with mercury, is to be introduced under the bell-glaſs, having the thumb placed upon the extremity of the ſyphon, to regulate the paſſage of the air, and by this means the air is gradually admitted, ſo as to let the mercury fall to its level. This being done, the bell-glaſs is to be carefully removed, the globules of melted iron contained in the cup, and thoſe which have been ſcattered about, and ſwim upon the mercury, are to be accurately collected, and the whole is to be weighed. The iron will be found in that ſtate called martial ethiops by the old chemiſts, poſſeſſing a degree of metallic brilliancy, very friable, and readily reducible into powder, under the hammer, or with a peſtle and mortar. If the experiment has ſucceeded well, from 100 grains of iron will be obtained 135 or 136 grains of ethiops, which is an augmentation of 35 per cent.

If all the attention has been paid to this experiment which it deſerves, the air will be found diminiſhed in weight exactly equal to what the iron has gained. Having therefore burnt one hundred grains of iron, which has acquired an additional weight of thirty-five grains, the diminution of air will be found exactly ſeventy cubical inches; and as it is known that the weight of vital air is very near half a grain for each cubical inch, the augmentation of weight in the one exactly coincides with the loſs of it in the other.

If it be required to examine the nature of the air which remains after this experiment, we muſt operate in a ſomewhat different manner. After the combuſtion is finiſhed, and the veſſels have cooled, we firſt take out the cup, and the burnt iron, by introducing the hand through the quickſilver, under the bell-glaſs; we next introduce ſome ſolution of potaſh, or cauſtic alkali, or of the liver of ſulphur, or ſuch other ſubſtances as are judged proper for examining their action upon the reſiduum of air. After this examination, ſo much water muſt be let into the glaſs as will diſplace the quickſilver; and then, by means of a ſhallow diſh placed below the bell-glaſs, it is to be removed into the common water pneumato-chemical apparatus, where the air remaining may be examined at large, and with great facility.

When very ſoft and very pure iron has been employed in this experiment, and when the combuſtion has been performed in the pureſt reſpirable or vital air, free from admixture of the noxious or mephitic part, the air which remains after the combuſtion will be found as pure as it was before; but it is difficult to find iron entirely free from a ſmall portion of charry matter, which is chiefly abundant in ſteel; and it is likewiſe exceedingly difficult to procure pure air perfectly free from ſome admixture of mephitics, with which it is almoſt always contaminated: that ſpecies of noxious air does not, as Mr. Lavoiſier affirms, in the ſmalleſt degree diſturb the reſult of the experiment, as it is always found at the end exactly in the ſame quantity as at the beginning.

The calcination of metallic ſubſtances by the action of acids, is evidently an operation of the ſame nature as that which is effected by heat and vital air. Numberleſs experiments have ſhewn that vital air is a component part of acids. But this being a modern diſcovery, the theory of phlogiſton was applied to the acids which were ſuppoſed to be capable of attracting or expelling that principle from metallic bodies as well as other ſubſtances. On this head the ſeveral articles relating to the acids and metals may be conſulted. It muſt nevertheleſs be admitted, that as the vital air is known to be a component part of acids, as they loſe a portion of it whenever they are employed to calcine any metal, as the calx is found to have gained this very principle, it appears unneceſſary or redundant to admit the phlogiſton in explaining theſe effects. The general facts of metallic ſolution are *,

1. The metals cannot unite with acids unleſs previouſly calcined, or united with the baſe of vital air. This therefore appears to be the medium of the union.

2. The degree of calcination for this purpoſe is definite. If too near the metallic ſtate, they are difficultly taken up, and if too much calcined they ceaſe to be ſuſpended.

3. This degree differs in the ſeveral metals.

4. In every metallic ſolution by an acid, the metal attracts and combines with vital air, either from the acid which is decompoſed, or from the atmoſphere which is rendered leſs ſalubrious, or elſe from the water which is decompoſed. See WATER. In the firſt caſe, one of the principles of the acid, or its baſe, is ſet at liberty, and uſually flies off, as ſulphur in the decompoſition of vitriolic acid, in the compoſition of vitriolic air, or either nitrous or azotic air when nitrous ſolutions are made. See ACID VITRIOLIC, ACID NITROUS. In the ſecond caſe, as in the acetous ſolution of copper, which only takes place when atmoſpheric or vital air is preſent, this laſt fluid is abſorbed. And in the third there is a diſengagement of inflammable air. It is deduced that the inflammable air is afforded by the decompoſition of the water, becauſe the acid is found, when diſengaged from the metal †, to be capable of forming as much neutral ſalt with an alkali as a like quantity of the ſame acid would do.

5. The marine acid, and ſuch vegetable acids as are compoſed of baſes which have a ſtronger attraction for vital air than the metals have, are not decompoſed by the metals, and accordingly they are not diſſolved unleſs water or vital air be preſent in ſufficient abundance. And theſe ſolutions either emit inflammable air, or do not effervesce at all.

6. The diſpoſition of theſe acids to unite with the calx or combination of metal and vital air greatly favours the attraction of that fluid. So that metals which would long remain expoſed to the air without calcination will attract vital air when in contact with an acid: and other metals, copper for inſtance, which is not capable of decompoſing water alone at any obtainable temperature, will effect it by the help of an acid.

There are ſome caſes in which the water and the acid are at the ſame time decompoſed by the metal, as in the ſolution of tin by the nitrous acid. Tin is ſo ſtrongly attractive of vital air, and requires ſo large a quantity for its ſaturation, that after having abſorbed that of the nitrous acid, and reduced it to the ſtate of azotic or phlogiſticated air, it decompoſes the water and diſengages inflammable air. Theſe two principles being thus ſeparated from their firſt compounds unite together, and form volatile alkali. See VOLATILE ALKALI. Hence there is no perceptible diſengagement of elaſtic fluid. In this caſe it appears, that the formation of volatile alkali, in the ſolution of tin by the nitrous acid, always takes place;

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* Fourcroy on Kirwan.

† This experiment was well performed by Dr. G. Fordyce with zinc and vitriolic acid. See Phil. Tranſ. or the article ZINC.

for by throwing quicklime or cauſtic fixed alkali into this ſolution, there is always a diſengagement of ammoniac.

7. It follows from all that has hitherto been ſaid, that in every metallic ſolution in which the acid is decompoſed, two doſes of this ſalt are required, of which the mind conceives the neceſſity. 1. That whoſe decompoſition ſupplies the metal with vital air. 2. That which diſſolves the calcined metal.

8. Hence, if no greater quantity of acid be added to a metal than is neceſſary for its calcination, it will be calcined and not diſſolved. Thus it is that a few drops of concentrated nitrous acid being thrown upon tin, antimony, biſmuth, and even zinc, quickly reduce the metals into white, dry, and pulverulent calces.

9. From this accurate diſtinction of the two doſes of acid, we ſee why a metal, though very greedy of vital air, does not decompoſe this acid ſufficiently, nor deprive it of enough of vital air to ſaturate itſelf; for if too highly charged with this principle, it would not unite to the undecompoſed portion of the acid, and there would be no ſolution; but inſtead of ſaturating itſelf in this manner, in proportion as the metal arrives at the determinate point of calcination, the acid diſſolves it, and the metal does not decompoſe it beyond that point, becauſe its affinity with the acid is then ſtronger than with a greater doſe of vital air.

10. Various circumſtances, and eſpecially an elevated temperature, change theſe attractions; they increaſe that of the metal for vital air; and by favouring its ſaturation with that principle, they either prevent its uniting with the acid, or effect its ſeparation: the former event takes place in the mixtures of acids and metals, whoſe mutual action is increaſed by a ſtrong temperature, and the latter takes place in moſt metallic ſolutions, when they are too ſtrongly heated.

11. Moſt metallic ſolutions, which are left expoſed to the air, abſorb vital air with more or leſs facility; and the metals which they contain, becoming more calcined than before, ſeparate and fall down; ſo that there is not one of theſe ſolutions which remains in the ſame ſtate if expoſed to air, or which can be conſidered as abſolutely permanent.

12. Since the metals cannot remain united to the acids, but in the ſtate of calces of a determinate degree, it is eaſily conceived, that by plunging into a metallic ſolution a metal which has a ſtronger affinity with vital air than that which is diſſolved, the former muſt deprive the latter of its vital air, take its place in the acid, and cauſe the ſecond to ſubſide in a form more or leſs metallic, accordingly as it has deprived it of more or leſs vital air. This is the reaſon of the precipitation of ſilver by copper, copper by iron, &c.

It may eaſily be perceived that the great queſtions relating to phlogiſton in the calcination, ſolution, and precipitation of metallic ſubſtances are intimately connected with the compoſition and decompoſition of water. On theſe ſubjects ſee WATER, PRECIPITATES, VEGETABLES.

PHOSPHORUS (ENGLISH), OR KUNCKEL'S PHOSPHORUS. The name phoſphorus is applied to all ſubſtances capable of giving light in the dark; ſuch as glow-worms, rotten-wood, diamonds after having been expoſed to the ſun or light; the Bolognian ſtone, and certain ſpars after calcination. The effects of theſe phoſphoric matters may proceed from electricity, or ſome property of light. We ſhall mention theſe in the following article. The phoſphorus we now treat of is of a very different nature. It is a ſubſtance not only luminous in the dark, but alſo inflammable and burning. It is the baſis of a peculiar acid, and is conſequently a ſpecies of ſulphur.

The diſcovery of this phoſphorus is not very ancient: it was diſcovered by a citizen of Hamburgh, called Brandt, in his reſearches for the philoſopher's ſtone. Kunckel was deſirous to acquire this ſecret, and for this purpoſe aſſociated himſelf with one of his friends, called Kraaft, who thinking by means of it to make a fortune, reſolved, after having procured it, not to reveal it, and even obtained a promiſe from the inventor not to communicate it to Kunckel. Kunckel, vexed by this treachery, reſolved to ſearch for the phoſphorus: and although he knew no more of the proceſs than that urine was the ſubſtance employed, he proſecuted this inquiry with ſuch zeal, that at length he made phoſphorus. This chemiſt took to himſelf very juſtly the honour of having diſcovered it, and was accordingly conſidered as one of the diſcoverers of it, with ſo much more reaſon, as he did not find it by chance, and without ſearching for it, as Brandt had done, but after a rational inquiry undertaken for this purpoſe. Accordingly Kunckel's name is affixed to this phoſphorus, which is commonly called the phoſphorus of Kunckel.

The celebrated Mr. Boyle has alſo had the reputation of having made this diſcovery. Thoſe who give him the credit of this ſay, that Boyle having ſeen a piece of phoſphorus in England in 1679, which Kraaft had brought thither to ſhew to the King and Queen of England, and having been informed only that this phoſphorus was produced from ſome matter belonging to the human body, attempted, like Kunckel, to diſcover the method of preparing it, and in the following year actually made a ſmall quantity, which he lodged with the Secretary of the Royal Society, who gave him a receipt for it. But Stahl, in a ſmall work called the Three Hundred Experiments, ſays, that Kraaft told him that he communicated the proceſs to Mr. Boyle. If this be true, Boyle has claimed the honour of a diſcovery to which he had no right; an imputation injurious to the reputation of a man ſo juſtly famous. But it muſt be acknowledged, that the truth of this imputation is very queſtionable. For Kraaft, who, as Stahl relates, was ignorant of chemiſtry, and who had been treacherous to Kunckel, was nothing in all this affair of phoſphorus, but a trader in ſecrets. For having purchaſed the ſecret of preparing phoſphorus, he ſold it again every where; and therefore no credit is to be given to the teſtimony of ſuch a man.

It is not indeed probable, that a man of ſuch undoubted integrity as Boyle would have communicated the proceſs to the Royal Society as his own, if this had been the caſe. Neither does the invention appear to be of that magnitude, as not to be eaſily hit upon by thoſe who were determined to ſpare no pains nor attention in the purſuit of diſcovery, as was the caſe with the chemiſts of that day, moſt of whom indulged extravagant hopes. The proceſs of Boyle conſiſted in nothing more than diſtilling urine, till the laſt volatile product came over, which is the phoſphorus; and he uſed no other artifice to facilitate the operation, than that of firſt evaporating the fluid part of the urine until it became of the conſiſtence of ſyrup. He then mixed this liquid with thrice its weight of fine ſand, and expoſed the whole to diſtillation for twelve hours, the fire being made as intenſe as poſſible for the laſt ſix hours.

Boyle communicated the proceſs for making phoſphorus to a German chemiſt called Godfreid Hantkwitz, who accordingly prepared it in London. Kunckel and he were then the only perſons who made any conſiderable quantity of it, and the latter made a lucrative trade of it. Stahl ſays, that he knew alſo this Mr. Hantkwitz, and conſidered him as a good practical chemiſt, and that he had an excellent laboratory in London. His deſcendant ſtill keeps a reſpectable chemiſt's ſhop in Southampton-ſtreet, Covent Garden, which has always been famous for the extreme purity of the articles ſold. The date 1680 is over the door.

Proceſſes for making phoſphorus were frequently publiſhed about that time. Mr. Hellot, in his Memoir on this ſubject, enumerates all that were then known, namely, the proceſs publiſhed by Boyle in 1680, in the Philoſophical Tranſactions, No. 196; that of Kraaft; for, after ſelling the ſecret to many perſons, he afterwards publiſhed it in a treatiſe concerning phoſphorus, written by the Abbé de Commieres, publiſhed in the Mercure Galant, for June 1683; that of Brandt, in a collection of Experiments and Obſervations of Dr. Hook, publiſhed by Mr. Derham in 1726; that of Mr. Homberg, in the Ancient Memoirs of the Academy in 1692, who ſays, that he had ſeen Kunckel make phoſphorus; and laſtly, the proceſſes found in the works of ſeveral chemiſts, particularly of Theikmeyer, Hoffman, and Neewentuit.

But notwithſtanding all theſe proceſſes, whether they were not ſufficiently complete, or too laborious and expenſive, no chemiſt, excepting Hantkwitz, made phoſphorus, and the operation ſtill continued a ſecret till the year 1737, when a ſtranger came into France, who offered to make phoſphorus. The miniſtry granted him a reward for his proceſs, which he accordingly communicated. Meſſrs. Hellot, Dufoy, Geoffroy, and Duhamel, all experimental philoſophers and chemiſts of the Academy of Sciences, executed this proceſs ſucceſsfully. Mr. Hellot wrote a diſtinct account of it, and publiſhed it amongſt the Memoirs of the Academy of Sciences for the year 1737; a large extract of which may be found in the Elements of Practical Chemiſtry.

Since the publication of the Memoir of Mr. Hellot, the proceſs of phoſphorus was no longer a ſecret. But as this operation has hitherto been rather curious than uſeful, and is alſo expenſive and troubleſome, Macquer ſays, he does not know that any French chemiſt repeated it at that time, excepting Mr. Rouelle, who ſoon afterwards began a courſe of chemiſtry, in which he undertook to make phoſphorus in the preſence of his pupils. Macquer was then preſent as one of theſe, and Hellot attended during the whole operation. The pupils continued there the whole night; but from a fault in the retort this firſt operation failed. However, in the year following Mr. Rouelle ſucceeded many times.

To make phoſphorus by Mr. Margraaf's proceſs, a kind of plumbum corneum is previouſly prepared, by diſtilling a mixture of four pounds of minium with two pounds of powdered ſal ammoniac, from which all the volatile alkali, which is very penetrating, is by this operation obtained. The reſiduum after the diſtillation, that is, the plumbum corneum, is to be mixed with nine or ten pounds of extract of urine boiled to the conſiſtence of honey. Margraaf requires that this urine ſhould be putrefied, which is unneceſſary according to Baumé's obſervation*. This mixture is to be made ſlowly in an iron caldron ſet upon the fire, and by frequently ſtirring the matters. Half a pound of powdered charcoal is then to be added, and evaporation is to be continued till the whole is reduced into a black powder. This powder is to be put into a retort, to extract from it, by a moderate and graduated heat, all the volatile products of urine; that is, volatile alkali, fetid oil, and an ammoniacal matter which adheres to the neck of the retort. In this diſtillation the heat is to be only raiſed ſo as to make the matter red hot. After the diſtillation, a black and friable reſiduum remains, from which the phoſphorus is to be extracted by a ſecond diſtillation, and a ſtronger heat. Before it is expoſed to another diſtillation, it may be tried, by throwing ſome of it upon hot coals. If the matter has been well prepared, a ſmell of garlic exhales from it, and a blue phoſphorical flame is ſeen, undulating along the ſurface of the hot coals.

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* Schloſſer (de ſale urinæ nativo) ſays, that a greater quantity of phoſphorus may be procured from freſh than from putrid urine. But Venel (Encyclop. tom. xiv. p. 923.) thinks it may be more eaſily obtained from putrefied urine; and Pott ſays, that urine when putrefied yields a larger quantity than when freſh.

This matter is to be put into a good earthen retort capable of ſuſtaining a violent fire. Margraaf recommends retorts of Waldenburgh, or thoſe which are made near Kirchan in Saxony; but in France, they uſe Heſſian retorts, although they have the inconvenience of allowing a large quantity of phoſphorus to tranſpire during the operation. Baumé ſecures his retorts with a covering of clay and hair. Our Staffordſhire potters make good earthen retorts for this purpoſe. See Coating.

Three quarters of the retort are to be filled with the matter which is to yield the phoſphorus. It is to be placed in the common furnace for diſtillation with a retort; excepting that, inſtead of being terminated by an ordinary reverberatory or dome, this ought to be terminated by the upper piece of an air-furnace, to which a tube is to be applied, the diameter of which ought to be from four to ſix inches, according to the ſize of the furnace, and the height from eight to nine feet. This apparatus, which Baumé uſes, is neceſſary for raiſing a ſufficient heat, and for the convenience of throwing in a ſufficient quantity of fuel through the door of the upper piece of the furnace. The retort ought to be well luted to a receiver of moderate ſize, pierced with a ſmall hole, and half full of water. For this purpoſe ordinary fat lute may be bound on with ſtrips of linen, dipped in a lute prepared with lime and whites of eggs. The hole in the furnace through which the neck of the retort paſſes ought to be well ſtopped with furnace earth. Laſtly, a ſmall wall of bricks is raiſed betwixt the furnace and receiver, to guard this veſſel againſt heat as much as is poſſible.

All theſe preparations being made the evening before the diſtillation is to be performed, we are then capable of proceeding to this operation, which is very eaſy. The retort is to be heated by ſlow degrees during an hour and a half; and then the heat is to be increaſed till the retort be red hot, and the phoſphorus begins to paſs in luminous vapours: when the retort is almoſt of a white-red heat, the phoſphorus paſſes in drops, which fall and congeal in the water at the bottom of the receiver. This degree of heat is continued till no more paſſes into the receiver. When a retort contains eight pints or more, this operation continues about five hours.

Margraaf's apparatus is ſomewhat different from that above deſcribed. He divides the whole quantity of matter from which the phoſphorus is to be obtained into ſix ſmall retorts, which he places in a furnace that he deſcribes. The advantage of this diviſion is, that if any accident happens to one retort, the whole matter is not loſt; and as the retorts are ſmaller, a leſs heat is required. If indeed much phoſphorus was to be made, this practice would be ſafe and excellent; but Macquer affirms, that the method above deſcribed of Baumé is very convenient when a large quantity of phoſphorus is not wanted, and that he has never ſeen it fail.

Phoſphorus does not paſs pure in this diſtillation, but is blackened by ſoot or coal, which it carries along with it: it may eaſily be purified and rendered white and fine by a ſecond diſtillation or rectification. This rectification is made in a ſmall glaſs retort, to which is adjuſted a ſmall receiver half full of water. A very gentle heat is ſufficient, becauſe phoſphorus once formed is very volatile:

and as the fuliginous matter with which it is ſoiled was raiſed merely by the violence of the heat, it remains at the bottom of the retort in this diſtillation, and the phoſphorus paſſes very pure.

The phoſphorus is then uſually divided into ſmall cylindrical rolls, for the convenience of uſing it. This is done by putting it in glaſs tubes immerſed in warm water. This very gentle heat is ſufficient to liquefy the phoſphorus, which is almoſt as fuſible as ſuet. It takes the form of the glaſs tubes, from which it may be taken out when it is cold and hardened. That it may be more eaſily taken out of the tubes, theſe muſt be ſomewhat of the form of fruſtums of cones. All theſe operations ought to be made under water, to prevent the inflammation of the phoſphorus.

The proceſs publiſhed by Hellot for the preparation of phoſphorus is only different from this in two reſpects; firſt, that his is only one operation, and not divided into two, as Margraaf's is; and, ſecondly, that he does not uſe plumbum corneum. The operation is certainly much facilitated by Margraaf's method of ſeparating the volatile matters of the urine by a previous diſtillation; becauſe after that, nothing more is requiſite but to apply heat ſufficient to raiſe the phoſphorus; which may be done in four or five hours, whereas without this previous operation the diſtillation laſts 24 hours. The advantage of the plumbum corneum was long a matter of doubt; but ſince it has been aſcertained, that the acid of phoſphorus exiſts in urine in two combinations, the explanation has become eaſy. This acid is combined with volatile alkali and with mineral alkali. The former ſalt is decompoſed by charcoal, and gives over phoſphorus with heat, which the latter does not. But when plumbum corneum, or the combination of marine acid with the calx of lead, is added, the marine acid ſeizes the mineral alkali, and forms common ſalt; part of the coal is employed in reducing the lead, and another part in reducing the diſengaged phoſphoric acid, which then comes over in the form of phoſphorus.

The proceſs for diſengaging phoſphorus from bones has already been deſcribed under the article phoſphoric acid, which ſee. The phoſphoric glaſs obtained in the firſt inſtance from bones, is not ſufficiently deprived of calcareous earth to be uſed in any other proceſs than that of making phoſphorus. For this purpoſe however it is not neceſſary to bring it to the conſiſtence of glaſs. The evaporation may be conveniently performed in a copper veſſel; and when the fluid has acquired the conſiſtence of ſyrup, it may be mixed with its own weight of charcoal in powder, and ſubmitted to diſtillation in a good earthen retort. Inſtead of applying a receiver, the neck of the retort may be immerſed in a baſon of water to a ſmall depth; and the phoſphorus, as it comes over, will fall in drops to the bottom. It is true that in the proceſs thus managed there will be apparently much phoſphorus burned by the admiſſion of the common air, which now and then paſſes into the neck of the retort, whenever the abſorption of the water cauſes its ſurface to fall below the aperture; but this quantity is really inconſiderable, and is compenſated by the ſimplicity and facility of the proceſs. The operator muſt be careful that the neck of the retort be not plunged to too great a depth; becauſe in this caſe the water would paſs into the body of the retort at the time of abſorption, before the ſurface of the water in the baſon had fallen ſufficiently to admit the air. The phoſphorus comes over as ſoon as the retort is red hot; and when the drops ceaſe, the whole apparatus muſt be ſuffered to cool. It has the form of reddiſh wax or tallow; and may be preſſed together under the water while it is yet warm. If this be done with the naked hand, great care muſt be taken, that no particle ſhall remain ſticking to the hands, or under the nails; as ſuch a particle, by taking fire when brought into the air, might produce very painful and diſagreeable conſequences. It may be moulded into ſticks, by putting the pieces into ſmall conical tubes of glaſs, cloſed at one end, and fixed upright in a piece of wood, the whole being immerſed under water: on heating the water, the phoſphorus will melt, and take the deſired form. The impurities that riſe to the upper ends of the tubes may be cut off when taken out, which muſt not be done till all is cool.

Phoſphorus may be had exceedingly pure by ſtraining it through a leather bag immerſed in hot water; or, which is ſtill better, by diſtilling it a ſecond time with a very gentle heat, as already mentioned. The blackiſh colour of phoſphorus is aſcribed to a portion of phoſphoric acid which is mixed with it. This diſappears almoſt entirely by boiling with a ſmall quantity of volatile alkali; and if the phoſphorus be boiled two or three ſucceſſive times in ardent ſpirit, it becomes perfectly tranſparent, and of a beautiful opal colour, with very little loſs of weight.

Phoſphorus muſt be kept in a bottle of water, to prevent its gradual combuſtion.

The method of procuring phoſphorus by diſtillation from urine was ſuperſeded by the eaſier method of Scheele, by which it is obtained from bones. This method is accordingly uſed by moſt chemiſts; but M. Giobert of Turin has ſince improved the proceſs with urine ſo much as to exceed in ſimplicity and cheapneſs that of Scheele; inſomuch that the phoſphorus may, without any offenſive operation, be procured with convenience and certainty in the courſe of a day, or even a few hours, if the quantity be ſmall. From the conſideration of what happens by the addition of plumbum corneum in the diſtillation of phoſphorus, this chemiſt inferred that the marine acid ſeized the volatile and mineral alkalis of the urine, while the diſengaged phoſphoric acid combined with the lead, and formed a compound conſiſting of two parts, both reducible by charcoal, but not both volatile and therefore ſeparable by heat. It might however be queſtioned, as far as could be deduced from experiment in the dry way, whether the charcoal were not originally concerned in the decompoſition, and whether the affinities were not different in a lower temperature, as is ſeen in other chemical facts. Hence it remained to be tried, whether the combination would equally take place in the humid way, or with pure urine, without any previous concentration by the diſguſting proceſs of evaporation. For if the decompoſition of the phoſphoric ſalts could be had by the intermedium of the marine ſalt of lead, or any other metallic ſalt, and the metal were to fall down in the form of an inſoluble compound with the phoſphoric acid; this compound might be edulcorated and expoſed to diſtillation with charcoal. M. Giobert had obſerved that the phoſphoric acid, by ſimple elective attraction, is capable of decompoſing the acetous and even the nitrous ſalts of lead. He had, therefore, every reaſon to expect ſucceſs by double affinity with urine. The ſucceſs was equal to his expectation. Sugar of lead, or the combination of lead with vinegar, was added to urine. A precipitate fell down, on which he poured vitriolic acid. The ſupernatant liquor being decanted, and ſaturated with volatile alkali, proved to be a phoſphoric ſalt, and the nearly inſoluble reſidue was vitriolated lead. From theſe facts it was clear, that the firſt precipitate was phoſphorated lead, that the vitriolic acid ſeized the lead, and diſengaged the phoſphoric, and that this laſt formed a neutral ſalt by the addition of volatile alkali.

This is a ready method of procuring phoſphorated volatile alkali for eſſays by the blow-pipe, and may be more cheaply performed by the addition of vitriolic ammoniac, which is the product of various operations, leſs expenſive than thoſe by which the acid and alkali are obtained ſeparate. Mild volatile alkali will alſo decompoſe the phoſphorated lead; but in this caſe a triple compound of phoſphoric acid, volatile alkali, and calx of lead is obtained. No ſuch effect happens with the vitriolic ammoniac.

As the phoſphorated lead affords phoſphorus by diſtillation with charcoal, ſo may the experiment be performed with advantage with other metallic ſalts. M. Giobert, however, found lead the beſt. The vitriol of zinc decompoſes the reſinous ſalts very well, but the volatility of this metal greatly embarraſſes the ſubſequent operation. For though the phoſphorus appears to riſe with rather more facility than the zinc, yet the greater part of the product is phoſphorated zinc, which ſublimes in the retort. Mercury is ſubject to an objection of a ſimilar kind.

The quantity of urine for making phoſphorus may be procured at the hoſpitals, or, if more convenient, at the ſtables; for M. Giobert did not find any difference of importance in the urine of men or horſes, or whether in health or ſick. He thinks freſh urine preferable to that which has putrefied, or at leaſt not inferior to it. A ſolution of lead is then to be made in the nitrous acid, and poured by a little at a time into the urine, until no more precipitate is afforded, as may be aſcertained in the uſual way by trial with ſmaller portions taken out. The whole mixture muſt then be diluted with much water to rarefy the extractive matter. By ſtraining through a cloth, the watery liquid is ſeparated from the precipitate. M. Giobert does not ſay whether it would be any object of profit to recover the nitrous ſalts from the ſolution. The precipitate is to be made into a paſte with charcoal, and well dried in an iron or rather a copper pot. It is then fit for diſtillation. An oily alkaline fluid firſt comes over, then a ſmall portion of empyreumatic oil, both which ariſe from the urine left in the interſtices of the precipitate. As ſoon as the oil has ceaſed to come over, the receiver muſt be changed, the fire raiſed, and a receiver with water (ſee APPARATUS) ſubſtituted, as in the ordinary method. The phoſphorus ſometimes begins to appear in about half an hour, and the accompliſhment of an operation, which affords 12 or 14 ounces of phoſphorus, is eaſily effected in eight hours. The author thinks that a leſs degree of heat is requiſite than in the proceſs with bones.

Sugar of lead may be uſed inſtead of the nitrous ſolution, in all places where its cheapneſs as an article of commerce may render it preferable. But in this caſe, much of the lead falls down in the form of calx, and it is alſo neceſſary to keep the urine for ſome hours in digeſtion (I ſuppoſe with heat) after the ſugar of lead is added. The precipitation of more calx may be in ſome meaſure remedied by the previous addition of vinegar.

M. Giobert remarks, that it is not eaſy to determine with exactneſs the quantity of phoſphorus obtained from a given quantity of the precipitate, as it ſeems in ſome meaſure to depend on the nature of the urine, and certainly upon the care uſed in the edulcoration. When the precipitate of lead is well waſhed and ſaturated completely with phoſphoric acid, he thinks his experiments indicate that 100 parts of the phoſphorated lead afford 14 or 18 parts of phoſphorus; The lead is found reduced in the retort, and in part repays the charges. The phoſphorus is ſoiled by the oily matter it diſſolves in paſſing through the neck of the retort, but it may be eaſily purified by the well known proceſſes.

The acidification of phoſphorus is treated of under the article Acid Phosphoric, which ſee.

Phoſphorus combines with the cauſtic fixed alkalis in a boiling heat, and forms an hepar; during which a peculiar elaſtic fluid is given out, which poſſeſſes the remarkable property of taking fire as ſoon as it communicates with the air of the atmoſphere. This air has evidently the ſame relation to phoſphorus as the common hepatic has to ſulphur; and, like that, it probably conſiſts of a ſolution of the phoſphorus in inflammable air. See Air Phosphoric.

Sulphur and phoſphorus unite by fuſion, and form a ſolid compound of a fetid ſmell, which burns with a yellow flame, and ſwells in water; at the ſame time communicating acidity to that fluid, and emitting a ſmell of hepatic air. All kinds of oils diſſolve phoſphorus, and are rendered luminous by it; ſeveral eſſential oils form a ſolution which takes fire by expoſure to the air, probably in conſequence of the emiſſion of phoſphoric air. The butter of wax, which conſiſts of wax deprived of part of its acid by diſtillation, is ſaid to be the propereſt material for producing this effect.

The combuſtible property of phoſphorus has been lately applied in various ways to procure fire; but the danger of ſpontaneous accenſion in improper ſituations, and the expence, have prevented its coming at all in competition with the ordinary method of flint and ſteel. The phoſphoric contrivances are a phoſphoric taper or match, and a bottle, the method of making which is as follows:

1. The moſt ſimple proceſs for making the phoſphoric matches conſiſts, in taking a glaſs tube, four inches long, and one line in diameter, cloſed at one end. A ſmall quantity of phoſphorus is introduced into the tube, and puſhed to its further end; after which a taper covered with a ſmall quantity of wax is introduced into the ſame tube. The open end is then hermetically ſealed, and the other end is plunged into boiling water. The phoſphorus melts, and fixes itſelf upon the match.

A line is drawn at one-third of the length of the tube, with a flint, that it may be broken as occaſion may require.

The match is to be drawn out quickly, to inflame the phoſphorus.

The proceſs of Mr. Lewis Peyla, to make the inflammable bougies, conſiſts in taking a glaſs tube, five inches long and two lines wide, one end of which is ſealed with the blow-pipe. Small tapers of wax are prepared with three double threads of cotton twiſted together. The extremity of the match or taper is half an inch long, and muſt not be covered with wax.

A piece of lead is laid in a ſaucer filled with water; and upon this the phoſphorus is cut, beneath the water, into fragments of the ſize of a grain of millet. One of theſe grains is to be dried and introduced into the tube of glaſs; after which the fortieth part of a grain of very dry ſulphur is to be added, that is to ſay, half the weight of the phoſphorus. One of the bougies is then taken, and its extremity dipped in very clear oil of wax. If too large a quantity riſes, it muſt be dried with a cloth.

The match is introduced into the tube, with a turning or twiſting motion between the fingers.

The bottom of the tube muſt then be plunged into boiling water to ſoften the phoſphorus; obſerving to keep it no longer than three or four ſeconds in the water.

The other extremity of the tube is afterwards ſealed.

Theſe bougies muſt be kept in a tin tube, to avoid the danger of inflammation.

2. To form the phoſphoric bottles, a glaſs bottle is heated by fixing it in a ladle full of ſand, and two or three ſmall pieces of phoſphorus are then introduced into it. A ſmall red-hot iron wire is uſed to ſtir the phoſphorus about, and cauſe it to adhere to the internal ſurface of the bottle, where it forms a reddiſh coating. The heated wire is introduced repeatedly; and when all the phoſphorus is thus diſtributed within the bottle, it is left open for a quarter of an hour, and afterwards corked. When this is uſed, a common match tipped with ſulphur is introduced into the bottle, turned round, and quickly drawn out. The phoſphorus which ſticks to the ſulphur takes fire, and lights the match.

The theory of this phenomenon depends on the circumſtance that the phoſphorus is ſtrongly dried or half calcined, and needs only the contact of air to ſet it on fire.

Very ſtrong ardent ſpirit diſſolves a portion of phoſphorus when cold, and more when heated, which is again ſeparated by cooling. Metals do not readily combine with this ſubſtance when ſimply heated with it; but when the phoſphoric acid, together with charcoal, is expoſed to a ſtrong heat, a conſiderable number of the metals may be made to unite with it, probably in conſequence of their being previouſly calcined by the acid. See the ſeveral metals.

Chaptal conjectures that the luminous matter of the glow-worm, lampyris ſplendidula Linnæi, and other lucid animals, is a combination of phoſphorus and oil. Forſter of Gottingen obſerves, that the ſhining matter of the glow-worm is liquid. If the glow-worm be cruſhed between the fingers, the phoſphoreſcence remains on the finger. Henckel reports, in the eighth diſſertation of his Pyritologia, that one of his friends, of a ſanguine temperament, after having danced much, perſpired to ſuch a degree that he thought his life in danger. While he undreſſed, traces of phoſphoric flame were ſeen on his ſhirt, which left yellow-red ſpots behind them, reſembling the reſidue of burnt phoſphorus: this light was long viſible.

PHOSPHORIC STONES, or EARTHY PHOSPHORI. Theſe ſtones when properly calcined have the property of ſhining in the dark. The moſt celebrated and moſt anciently known phoſphorus of this kind is that called the Bolognian ſtone, from Bologna, a city of Italy, near which this ſtone is found. See Bolognian Stone. It is the ponderous ſpar.

The marine ſalt of lime is eaſily fuſed, and, being poured into a clean iron mortar, appears when cold of a yellowiſh white colour, and ſemi-tranſparent like horn. It is luminous when ſtruck in the dark, and thence was called a phoſphorus by Homberg. The experiment does not always ſucceed, probably for want of combuſtible matter, which is uſually preſent when this compound is obtained from the reſidue of impure ſal ammoniac diſtilled from lime. Solution of chalk in the nitrous acid forms on evaporation a tenacious maſs like turpentine, which, dried and calcined a little, proves luminous in the dark. This phoſphorus is uſually diſtinguiſhed by the name of its firſt diſcoverer, Baldwin: it is called alſo phoſphorus hermeticus, from its being kept in hermetically ſealed glaſſes to ſecure it from the air. It differs from ſome other natural phoſphori, in appearing in ſome degree luminous after expoſure to the light of a taper, as well as of the ſun.

The effect of the earthy phoſphori ſeems to depend on a degree of ſlow combuſtion, not yet well explained. Theſe ſubſtances ſeem to reſume vital air and moiſture from the atmoſphere, and emit light either on the principle of common combuſtion, or from previous abſorption. According to this laſt opinion, the ſhining of phoſphori, after expoſure to light, is not a mere combuſtion produced by the action of the luminous body, but an abſorption and emiſſion of the matter of light.

The late Mr. Canton gave a receipt for making an artificial phoſphorus, greatly ſuperior to any ſingle natural ſubſtance, with the additional advantage of being very eaſily and cheaply prepared. His receipt is as follows: Calcine ſome common oyſter ſhells, by keeping them in a good coal fire for half an hour, and let the pureſt part of the calx be pulverized and ſifted. Mix with three parts of this powder, one part of the flowers of ſulphur; let this mixture be rammed into a crucible of about an inch and a half in depth till it be almoſt full, and let it be placed in the middle of the fire, where it muſt be kept red-hot for one hour at leaſt, and then ſet by to cool. When it is cold, turn it out of the crucible, and, cutting or breaking it to pieces, ſcrape off, upon trial, the brighteſt parts; which, if good phoſphorus, will be a white powder, and may be preſerved by keeping it in a dry phial with a ground ſtopple.

The quantity of light which a little of this phoſphorus gives, when firſt brought into a dark room, after it has been expoſed for a few ſeconds on the outſide of a window, to the common light of the day, is ſufficient to diſcover the time by a watch, if the eyes have been ſhut, or in the dark, for two or three minutes before.

By this phoſphorus celeſtial objects may be very well repreſented, as Saturn and his ring, the phaſes of the moon, &c. if the figures of them made of wood, be wetted with the white of an egg, and then covered with the phoſphorus. And theſe figures appear to be as ſtrongly illuminated in the night, by the flaſh from a near diſcharge of an electrified bottle, as by the light of the day.

John Baptiſt Beccaria diſcovered that the ſulphureo-calcareous phoſphorus imbibed the peculiar coloured rays to which it had been expoſed. Thus having expoſed different phoſphoric pieces to rays of the ſun, tranſmitted through green, yellow, and red cryſtals, he obſerved that each of them, when afterwards viewed in the dark, exhibited that colour to which it had been expoſed.

PIMENTO. See PEPPER (JAMAICA).

PIPE-CLAY. The difference between the porcelain clay and thoſe of more moderate purity, called pipe-clays, of which we have plenty in Devonſhire, is commonly, that the former remains white when burned in an open fire; but the latter, containing a portion of mineral oil, becomes of a blueiſh-gray in a moderate heat, by the coal produced by this combuſtion. A ſtronger heat, however, will perfectly conſume this coal, and reſtore the whiteneſs. On the whole, however, it appears rather as if this diſtinction between the clays uſed in pottery were grounded on the nature of the product they afford, than on any very evident property aſcertainable before they are wrought and baked.

PISOLITHES. A ſtalactitical calcareous ſtone of a gray colour, ariſing from calx of iron.

PITCH. Tar boiled down to dryneſs is the common black pitch: this part of the proceſs is commonly performed in a ſtill, in order to ſave an eſſential oil which ariſes in the boiling, and which is called, from the name of the tree which tar is principally prepared from, oleum pini, and oleum tædæ. This oil is greatly valued by painters, varniſhers, &c. on account of its drying quality: it ſoon thickens of itſelf, almoſt to the conſiſtence of a balſam. Along with the oil there comes over a watery liquor, which the workmen injudiciouſly throw away: it is a good acid ſpirit, capable of being applied to ſundry uſeful purpoſes. Neumann knew a perſon in France who ſaved by it ſeveral thouſand dollars.

Pitch is not a pure and perfect reſin: it has not only ſuffered a notable change from the heat employed in its preparation, but likewiſe participates of the other principles of the wood of a gummy and ſaline nature, and of a burnt earth. Hence its diſpoſition to ſeparate and precipitate when melted with oils, fats, and reſins, into plaſters and ointments; and hence it is gradually corroded by air and moiſture, when employed as a cement or defence for wood or other ſubſtances, in ſhips, land-carriages, ciſterns, caſks, ſhingle coverings for houſes, &c. Ship-builders endeavour to improve their tar and pitch, ſo as to render them more durable, by various additions.

Two ounces of dry pitch treated by Neumann with rectified ſpirit of wine, gave but one ounce and half a ſcruple of reſinous extract: half an ounce of empyreumatic oil ſeparated during the digeſtion, and there remained undiſſolved half an ounce of earthy matter, from which water would extract nothing. The ſame quantity of the ſame pitch boiled at firſt in water, yielded two drams and half a ſcruple of gummy extract; from the remainder nevertheleſs were obtained ten drams of ſpirituous extract, that is, near two drams more than when ſpirit was applied at firſt, the indiſſoluble part amounting as before to half an ounce. The diſtilled water ſmelled and taſted almoſt like red herrings: the ſpirit had no remarkable impregnation. Eight ounces of pitch, diſtilled in an open fire, yielded two ounces one dram and a half of an acid ſpirit, and two ounces five drams of a fetid oil, three ounces of a ſhining black coal remaining in the retort.

The ſoot which ariſes in the burning of pitch, is the ſubſtance commonly ſold under the name of lamp black: in France, the pitch is burnt for this purpoſe in a kind of furnace made of tiles, ſo diſpoſed as to prevent the eſcape of the ſmoke.

Lewis informs us that what is called lamp-black (originally the ſoot collected from lamps) is obtained, in different parts of Germany, Sweden, &c. not from pure reſin or pitch, but from the dregs and pieces of bark of the tree ſeparated in their preparation. For making common reſin, the impure juice collected from inciſions in pines and fir-trees, is boiled down with a little water, and ſtrained whilſt hot through a ſack: on cooling, the reſin congeals upon the ſurface of the water, and is then packed up in barrels; it is diſtinguiſhed according to its colour, into white, yellow, and brown. The droſs left on ſtraining, is burnt for lamp-black, in a low oven, from which the ſmoke is conveyed by a long paſſage into a ſquare chamber, having an aperture in the top, upon which a large ſack is faſtened: the ſoot concretes partly in the ſack, which is occaſionally removed, and partly in the chamber and canal, from which it is ſwept out.

Lamp-black is more oily or reſinous than the common wood ſoot: it gives out more to ſpirit and leſs to water by infuſion, and yields a larger quantity of oil on diſtillation. Mixed with boiled oil, and a little boiled turpentine, it forms the black compoſition uſed as ink in printing. See INK, alſo PYROPHORUS.

PITCH-BLENDE. See PECH-BLENDE.

PITCH (JEWS). See ASPHALTUM.

PIT-COAL. See COAL.

PLANTS. See VEGETABLE KINGDOM.

PLASTER OF PARIS. See EARTH CALCAREOUS.

PLATINA is one of the metals for the diſcovery of which we are indebted to our contemporaries. It has yet been found only in Spaniſh America among the gold mines there. We receive it in the form of ſmall particles, from the minuteſt ſize up to that of a pea; though theſe laſt are very ſeldom met with. Its particles or grains are ſmooth, irregularly figured with round edges, and are flattened, probably by hammering in the mills in which the gold is amalgamated. Theſe grains are of a whiter colour than iron, and are conſiderably malleable. In the ſtate in which we receive them, they are often mixed with ferruginous ſand, which may be ſeparated by the magnet; and alſo with grains of quartz or cryſtal. When it is ſeparated from heterogeneous particles, the crude platina itſelf is ſlightly magnetic, and is between ſixteen and eighteen times as heavy as water. The moſt violent fires are inſufficient to melt it, though its parts may be made to cohere together into a ſolid button by the ſtrong heat of a wind furnace. Burning lenſes of the moſt powerful kind fuſe it, and convert it into a malleable metal; and ſmall portions of crude platina may be eaſily melted upon charcoal, by flame urged by a ſtream of vital air.

Pure or refined platina is by much the heavieſt body in nature. It is very malleable, though conſiderably harder than either gold or ſilver; and it hardens much under the hammer. Its colour on the touch-ſtone is not diſtinguiſhable from that of ſilver. When in the higheſt degree of purity, it is not magnetical; but when its ſpecific gravity is as low as 21.36 it contains iron ſufficient to render it magnetical. Pure platina requires a very ſtrong heat to melt it; but when urged by a white heat, it is ſaid that its parts will adhere together by hammering. This property, which in iron is diſtinguiſhed by the name of welding, is peculiar only to platina and that metal, which reſemble each other likewiſe in their infuſibility.

Platina is not altered by expoſure to air; neither is it acted upon by the moſt concentrated ſimple acids, even when boiling, or diſtilled from it. The dephlogiſticated or aerated marine acid diſſolves it, as does likewiſe aqua regia; and both are ſaid to form the ſame ſalts with it. In this particular of ſolubility platina reſembles gold.

The aqua regia beſt adapted to the ſolution of platina, is compoſed of equal parts of the nitrous and marine acids. The ſolution does not take place with rapidity. A ſmall quantity of nitrous air is diſengaged, the colour of the fluid becoming firſt yellow, and afterwards of a deep reddiſh brown, which, upon dilution with water, is found to be an intenſe yellow. This ſolution is very corroſive, and tinges animal matters of a blackiſh-brown colour: it affords cryſtals by evaporation. The metal is precipitable from its ſolution by ſal ammoniac; a property by which it is diſtinguiſhed from all other metals, in the ſame manner as the ſolution of gold is characterized by its precipitation upon the addition of martial vitriol. In this way, a compound ſolution of gold and platina may be ſeparated by precipitating either of the two metals at pleaſure. The orange-coloured precipitate of platina, obtained by means of ſal ammoniac, is a ſaline ſubſtance, completely ſoluble in water; but its component parts have not been well aſcertained. It is fuſible without addition by a good forge furnace, and forms a brilliant, denſe, and cloſe-grained button, which is not malleable, probably on account of part of the ſaline ſubſtance not being diſſipated.

The ſame precipitate expoſed to the ſtronger heat of a blaſt furnace, was fuſed into a perfectly malleable regulus by the Count de Milly. See Magellan's Cronſtedt, page 574. I have ſeveral ſpecimens of this platina, which is in thin plates or bars; their ſpecific gravity is above 21½; in which I do not pretend to a greater accuracy than 1-200th part of the weight, becauſe the quantities are ſo ſmall. It is perfectly malleable, hard, and elaſtic, and obeys a ſtrong magnet when the pieces are floated upon water: one ſmall piece which was fuſed by Parker's lens is not at all magnetical, and ſeems to exceed 22 in ſpecific gravity. Dr. Ingenhouſz poſſeſſes maſſes of platina of ſeveral ounces produced in this way and by welding. For this laſt purpoſe the maſs at the white end is put into a tube of iron, and ſuddenly compreſſed together by a heavy blow. This platina is very malleable, and has been made into ornaments, fine wire, and other articles.

Alkalis, and the ſoluble earths, decompoſe the ſolution of platina, and precipitate the metal in the form of a calx. Mild vegetable alkali produces an orange precipitate in the ſolution of platina. This precipitate is not a calx of pure platina. Meſſrs. Macquer and Baumé have obſerved, that it owes its colour to its containing a certain quantity of acid. It is therefore to be conſidered as a mixture of calx of platina with muriated vegetable alkali, or a kind of triple ſalt. A proof of this opinion is, that when this precipitate is waſhed with hot water, the fluid acquires a colour by diſſolving the ſalt of platina, and the reſidue is pure calx of platina of a gray colour. Fixed alkali, boiled on this precipitate, inſtantly deprives it of its colour, leaving a calx of platina, of a gray-white pearl colour, according to the experiments of M. Baumé. That chemiſt aſcertained that the precipitate of platina is ſoluble in alkali; for, on pouring a ſolution of the metal into a hot ſolution of mild vegetable alkali, he found no precipitate produced: and the ſolution, precipitated by fixed alkali, always retains, on this account, a deep colour; and platina may be eaſily obtained by evaporating it to dryneſs. Margraaf diſcovered, that ſoda does not precipitate the ſolution of platina: but Bergman has obſerved, that on putting into it a great quantity of this alkali, there is a precipitate ſpeedily enough produced.

Bergman informs us that an alkaline pruſſiate, highly ſaturated and very pure, does not precipitate the ſolution of platina; and that this metal is the only one not liable to be precipitated by this re-agent; and he therefore propoſes it for ſeparating the iron, which is always in union with platina.

Cauſtic volatile alkali produces an orange precipitate in the ſolution of platina. This precipitate is almoſt entirely ſaline; for water diſſolves moſt part of it, taking a colour like that of the ſolution of gold. After the water has acted on this precipitate, there remains a blackiſh ſubſtance, which appears to be ferruginous. One eſſential difference between the precipitate of platina and that of gold by ammoniac is, that the former is not fulminating like the latter.

Infuſion of the nut-gall produces, in the ſolution of platina, a deep green precipitate, which becomes gradually pale by reſt.

All precipitates of the ſolution of platina obtained by alkaline matters, are unfit for vitrifying and colouring glaſs by furnace fires. In the attempts made by Meſſrs. Lewis and Baumé to accompliſh this, the platina was always reduced to grains, which were arranged in ramifications, or a kind of checquer work. Platina may be obtained in a ſort of button, by expoſing theſe precipitates to heat, together with ſome reductive fluxes, ſuch as borax, cream of tartar, glaſs, &c. Meſſrs. Macquer and Baumé melted in five-and-thirty minutes, at a forge fire blown by two ſtrong bellows, a precipitate of platina mixed with theſe fluxes. They obtained, in a hard blackiſh glaſs like bottle-glaſs, a brilliant button of platina, which appeared to have been in fuſion. This button was not ductile: it broke into two pieces; in conſequence of which it was obſerved to be hollow within. It was nearly of the ſame hardneſs with forged iron, and made deep ſcratches in gold, in copper, and even in iron. Notwithſtanding what has been obſerved of precipitates of platina, as not being liable to vitrify or mix with glaſs, Baumé melted them into a vitriform matter by two different proceſſes. The precipitate of platina, mixed with calcined borax and a very fuſible white glaſs, and expoſed for ſix-and-thirty hours to the heat of the hotteſt place of a furnace for pottery, afforded him a greeniſh glaſs, inclining to yellow, and containing no globules of reduced metal. This glaſs being treated anew with cream of tartar, gypſum, and potaſh, was thoroughly melted, but contained ſmall globules of platina diſperſed through it. M. Baumé ſeparated them by waſhing, and found them to be ductile. He then, in conjunction with M. Macquer, expoſed precipitate of platina in the focus of the ſame burning glaſs with which they had melted the metal. The precipitate emitted a very thick luminous ſmoke, which diffuſed a ſtrong ſmell of aqua regia: it loſt its red colour, and reſumed the natural colour of platina; and it melted into a gloſſy ſparkling button, which button conſiſted of an opake vitreſcent matter of an hyacinth colour on the ſurface, and blackiſh internally, and may be conſidered as a real glaſs of platina. Fourcroy, notwithſtanding, very properly remarks, that the ſaline matters with which it was impregnated, muſt, without doubt, have contributed to its vitrification.

The precipitate of platina does not appear to be ſoluble in ſimple acids; but it diſſolves readily in the aqua regia, to which it communicates only an orange colour; never a brown like platina in grains.

Meſſrs. Margraaf, Baumé, and Lewis mixed the ſolution of platina with ſolutions of the other metallic ſubſtances. From theſe experiments it appears, that almoſt all metals precipitate platina in a brick-red or a brown powder; and that, agreeably to what happens to moſt other metals, none of theſe precipitates poſſeſs the properties of a metal. In this there is an analogy between gold and platina; with tin, however, platina does not give a purple, but a brown precipitate inclining to red. Solutions of biſmuth and lead by the nitrous acid, of iron and copper by any of the acids, and of gold by aqua regia, produce none of them any precipitate in the ſolution of platina, according to Margraaf: but again, ſolutions of arſenicated vegetable alkali, of nitre of zinc, and nitre of ſilver, are capable of precipitating the ſolution of platina: with the firſt it yields a ſcanty cryſtallized precipitate of a beautiful golden colour: with the ſecond, an orange-red matter; and with the third, a yellow matter. Theſe different precipitates have not been yet carefully examined, nor is it known by what decompoſition they are produced.

This metal is ſcarcely affected in the dry way by ſaline ſubſtances, nor by ſulphur, though it is ſaid to be diſſolved by liver of ſulphur. Nitre, according to the experiments of Lewis and Macquer on the crude grains, affects platina in a peculiar manner. Calx of arſenic facilitates its fuſion, and the ſemi-metal forms a brittle compound with the platina. Mr. Achard ſucceeded in making crucibles of platina, by fuſing equal parts of platina, white arſenic, and vegetable alkali. This matter, when cooled, was reduced to a powder, and rammed into the mould of the veſſel intended to be formed. A ſtrong heat, quickly raiſed, and continued for ſome time, fuſed the maſs; and, after diſſipating the arſenic and the alkali, left the platina in the form deſired.

No detonation takes place when a mixture of nitre and platina is caſt into a crucible; but when a mixture conſiſting of one part of platina and two of nitre is expoſed for a conſiderable time to an intenſe heat, as Lewis expoſed it for three days and three nights ſucceſſively, the metal takes a ruſty appearance. If this mixture be boiled in water, the fluid diſſolves the alkali, which carries with it a browniſh powder; and the platina ſeparated by this waſhing is found to be one-third leſs than the original quantity. The brown powder may be ſeparated from the alkali by filtration. This powder appears to be a kind of calx of platina mixed with a little calx of iron. Lewis cauſed it to take a whitiſh-gray colour, by diſtilling it many times ſucceſſively with ſal ammoniac. Margraaf repeated this valuable experiment, and has added two important facts: platina combined with alkali of nitre, and diluted in a certain quantity of water, forms a jelly: a portion of the metal, ſeparated from this jelly by dilution in water and filtration, takes a black colour like pitch. From theſe circumſtances it appears, that the platina ſuffers in this proceſs ſome great alteration: and it is to be wiſhed, as Fourcroy remarks, that theſe experiments were farther proſecuted in order to determine whether, by repeated calcination with nitre, this metal might be wholly reduced to a brown powder; as alſo to aſcertain the ſtate of the platina thus calcined.

The reſult of Dr. Lewis's experiments with crude platina and the metals is thus abridged by Macquer:

Equal parts of gold and platina may be melted in a violent fire, and the allay which is formed may be eaſily poured into an ingot mould. It is whitiſh, hard, and may be broken by a violent blow. Nevertheleſs, when it has been well annealed, it is capable of conſiderable extenſion under the hammer. One part of platina and four parts of gold may be melted and allayed with a much leſs fire than is requiſite in the preceding experiment. This allay is ſo ductile, that it may be extended into very thin plates without being broken, or even ſplit at the edges. Dr. Lewis obſerved a remarkable circumſtance concerning this allay, namely, that the platina, which was $\frac{1}{5}$ of the whole maſs, rendered the gold no paler than guineas are, which contain only $\frac{1}{12}$ of ſilver.

Silver and platina may be melted and allayed together in equal parts with a very violent fire. The allay which is formed is much harder and darker coloured than ſilver, and of a large grain, although it preſerves ſome ductility. Theſe qualities are leſs ſenſible when one part of platina is added to ſeven parts of ſilver: but this allay is ſtill coarſer grained and leſs white than ſilver. This coarſeneſs of grain ſhews an imperfect union; and indeed ſilver and platina do not ſeem to unite very intimately; for Dr. Lewis obſerves, that when the allay of theſe two metals was left after fuſion in the crucible, a conſiderable part of the platina was ſeparated and ſunk to the bottom. The platina did not appear to communicate any good quality to the ſilver, excepting a greater hardneſs.

Copper ſeems to be moſt improved by being allayed with platina. When indeed a large proportion of platina is added to copper, as equal parts or two-thirds, the allay is hard, brittle, and coarſe: but when a leſs quantity of platina is added, as from $\frac{1}{6}$ to $\frac{1}{25}$, or even leſs, a golden-coloured copper is produced, very malleable, harder, ſuſceptible of a finer poliſh, ſmooth-grained, and much leſs ſubject to calcination and ruſt than pure copper.

Dr. Lewis was not able to fuſe forged iron with platina, which is not ſurpriſing, when we conſider the refractory qualities of theſe two metals: but he allayed platina with caſt-iron by adding one part of platina to four parts or more of the iron when it was juſt beginning to flow. This allay was much harder, and much leſs ſubject to ruſt, than pure iron. It was ſuſceptible of a very fine poliſh.

Platina may be melted with tin in all proportions from equal parts of the two metals to twenty-four parts of tin. This allay was obſerved to be much harder, more brittle, more dark-coloured, and coarſer, as the proportion of the platina was larger. No advantage ſeemed to be attainable by this allay. Lead alſo may be allayed in different proportions with platina, nearly as tin may, with this difference, that a much greater fire is neceſſary for the formation of this latter allay, particularly when the quantity of platina is great. The metal reſulting from it has a dark colour, ſomewhat approaching to a purple or violet, or it eaſily acquires theſe colours when expoſed to the air. When the two metals fuſed together are left in a crucible to cool, a conſiderable part of the platina ſeparates and falls to the bottom, in the ſame manner as it does from the allay of ſilver.

From Dr. Lewis's experiments, platina appears to be capable of amalgamating with mercury, but difficultly, and by a very long trituration with water, as for inſtance, during a week.

If mercury be triturated with an allay of gold and platina, it ſeizes the gold, and does not touch the platina. Dr. Lewis propoſes this amalgamation as a method of ſeparating theſe two metals; and it is that which is employed with the ores of Peru, in which gold and platina are mixed together: but we do not yet know whether this ſeparation be perfectly complete.

Platina may be allayed with biſmuth nearly as with lead, and in a ſimilar manner ſeparates from the biſmuth after fuſion. It gives to biſmuth alſo, as it does to lead, the property of acquiring, by expoſure to air, violet, purple, or blue colours. This allay is always very brittle.

Of all metallic matters zinc may be moſt eaſily allayed with platina, and moſt effectually diſſolved by fuſion. Dr. Lewis obſerved, that theſe allays did not appear very different from pure zinc; but that when the proportion of platina is conſiderable, their grain is cloſer, their colour leſs clear, and more blueiſh, than that of zinc. They do not tarniſh, nor change colours by expoſure to air. Laſtly, they are harder than zinc, and have not the ſemi-malleability of this ſemi-metal.

With regulus of antimony platina formed a darker and harder compound than the pure regulus.

Dr. Lewis has combined platina at the ſame time with two metallic matters, ſuch as with braſs compoſed of copper and zinc, and with bronze compoſed of copper and tin. The moſt ſingular phenomenon of this latter allay was, that the copper and tin acting conjointly upon the platina were capable of diſſolving more of it than they both could do ſeparately. This allay was hard, and capable of receiving a fine poliſh, but is ſubject to tarniſh, which ſeems to happen to all the allays of tin or of lead with platina.

Equal parts of platina and braſs formed a compound very hard and very brittle, capable of receiving a very fine poliſh, and not ſubject to tarniſh. It might therefore be employed for ſpeculums of teleſcopes, and would be much preferable to thoſe now uſed, all which have the great diſadvantage of tarniſhing by expoſure to air, even very quickly.

Dr. Lewis does not mention the effects of allaying platina with arſenic; but Scheffer affirms, that if only a twentieth part of arſenic be added to platina when red-hot in a crucible, theſe two ſubſtances will be perfectly fuſed, and will form a brittle gray maſs. This remarkable experiment requires confirmation: for Margraaf having alſo treated theſe two matters together, did not perceive any ſuch action of arſenic upon platina. From one of his experiments we find, that having expoſed to a violent fire during an hour, a mixture of an ounce of platina with a fuſible glaſs, compoſed of eight ounces of minium, two ounces of flints, and one ounce of white arſenic, he obtained a regulus of platina, well united and fuſed, which weighed an ounce and thirty-two grains, the ſurface of which was ſmooth, white and ſhining, and the internal parts gray, but which nevertheleſs appeared ſufficiently white when it was filed.

The cupellation of platina was one of the moſt important experiments to be made; becauſe, if this operation ſucceeded perfectly, we might thereby obtain compact and malleable maſſes of pure platina, in the ſame ſtate as a metal which had been well fuſed, and of which all ſorts of utenſils might be made, if not by caſting it, at leaſt by forging. All the chemiſts who have examined this metal, and particularly Dr. Lewis, have uſed their utmoſt endeavours to cupel it well. But although they uſed every expedient to apply the ſtrongeſt heat, they did not perfectly ſucceed. The ſcorification proceeds well at the beginning of the operation, as when gold and ſilver are cupelled: but the cupellation afterwards becomes more and more difficult; becauſe, as the quantity of lead diminiſhes, the matter becomes leſs and leſs fuſible, and at laſt ceaſes to be fluid, notwithſtanding the moſt violent heat; and alſo becauſe, when the quantity of platina is greater than that of the lead, this latter metal is protected, and is not converted into litharge. Hence the regulus obtained is always dark-coloured, rough, adhering to the cupel, brittle, and weighing more than the platina originally employed, from the lead which remains united with it. Meſſrs. Macquer and Baumé kept the matter expoſed to a violent fire during a longer time, that is, about fifty hours ſucceſſively; therefore, although their platina was tarniſhed and rough on its ſurface, it was entirely white and ſhining, eaſily ſeparable from the cupel, and a little diminiſhed in weight: a certain proof that no lead remained in it. This platina was alſo ductile, and capable of extenſion under the hammer.

The commerce of platina has been prohibited by the Spaniſh miniſtry, from an apprehenſion that it might be employed in the adulteration of gold. Whether this prohibition has ſince been taken off I know not; but it ſeems needleſs, as the mixture of platina greatly alters the obvious qualities of gold, and can be very readily aſcertained by the teſt of ſal ammoniac before pointed out.

PLUMBAGO, or black lead, is a well known ſubſtance, of a black colour, and ſhining appearance when cut. Its texture is rather ſcaly, but its fracture exhibits a granular and dull appearance. None of the ſpecimens have any conſiderable hardneſs. This mineral is found in England, Germany, France, Spain, and Africa; but the ſort beſt adapted for making pencils comes chiefly from Borrowdale in Cumberland. For this purpoſe, it is carefully ſawed into narrow ſlips, or pieces, not more than one-tenth of an inch thick; which are glued between two half cylinders of cedar wood. An inferior kind of pencils is made by the Jews, by mixing the powder or ſaw-duſt with gum arabic, or fuſing it with reſin or ſulphur; and preſſing or pouring it into the cavities of reeds. The powder of plumbago, with three times its weight of clay, and ſome hair, makes an excellent coating for retorts; and the black lead or Heſſian crucibles are compoſed of the ſame materials.

Plumbago is not ſubject to alteration by expoſure to the action of air or water; and it is inſoluble in acids. In cloſed veſſels it is either entirely or nearly unalterable by the ſtrong heat of a furnace; but by continued ignition, and occaſional ſtirring in a ſhallow veſſel, under a muffle, it is gradually diſſipated, or burned, leaving a reſidue of calx of iron, of about one tenth of the original weight. It detonates with nitre in a red heat; ten parts of this ſalt are required to one of plumbago before the whole will be decompoſed, and exhibit no reſidue of plumbago when the alkali is diſſolved in water. The aerial product of this detonation is found to conſiſt of a mixture of one-third fixed air; and the reſt air which maintains combuſtion: the alkali contains fixed air, and ſome of the nitre is driven up by the heat. In order to ſhew that the fixed air came from the plumbago, and not from the nitre, the firſt analyſer * of this ſubſtance detonated tin, antimony, and ſulphur, reſpectively, with nitre, and obtained no fixed air: and, ſtill more to place the inference beyond a doubt, he expoſed plumbago to diſtillation, with twice its weight of dry acid of arſenic: the acid was reduced to the ſtate of white calx, and ſublimed; and pure fixed air came over. Similar reſults were had with the calces of mercury and lead; the metals were revived, and fixed air was expelled. When pulverized plumbago was diſtilled with cauſtic fixed alkali by a ſtrong heat, the volatile product was inflammable air; and the remaining alkali contained fixed air.

From theſe and other facts he concluded, that plumbago is a compound of phlogiſton and fixed air, with a little iron, which he ſuppoſed to be accidental. The exiſtence of the phlogiſton was judged to be proved by its detonation with nitre, as well as by the revival of the acid of arſenic and the metallic calces, and the extrication of inflammable air by alkali: he inferred the quantity of phlogiſton in this ſubſtance to be twice as much as in charcoal; becauſe it requires twice the quantity of nitre for its detonation. The preſence of fixed air was deduced from the aerial products in all the diſtillations but the laſt; and from the mild ſtate of the alkalis, in thoſe trials wherein they were uſed.

The antiphlogiſtic philoſophers † conſider plumbago as a compound of iron, and the acidifiable baſe of fixed air, which they call carbone, becauſe it exiſts moſt abundantly in charcoal. The difficulty of burning or decompoſing it, is conſidered as a conſequence of the combination of its parts, which are leſs diſpoſed to unite with vital air than either would be if alone. The ſame difficulty accounts for the large proportion of nitre required to deflagrate with it completely; a quantity required, not becauſe there is much combuſtible matter to be burned, but becauſe a long continued and elevated heat is neceſſary; by which means much of the nitre is decompoſed, and its vital air flies off, without having been employed in the combuſtion, as appears by the two-thirds of the elaſtic product which will ſupport the flame of a candle. The other facts are eaſily adapted to this theory. By detonation with nitre it affords fixed air, becauſe the combuſtible baſe is acidified by the vital air of the nitre. The arſenical acid, and metallic calces, are reduced by the abſtraction of the vital air they contain; which vital air, combining with the acidifiable baſe contained in the plumbago, converts it into the fixed air, or acid, which flies off: and laſtly in the diſtillation of plumbago with humid alkali, a decompoſition of the water takes place: its inflammable air flying off, and its vital air combining with the acidifiable baſe, as before, forms fixed air, which unites with the alkali, and renders it mild.

The chief difference in the matter of fact between theſe theoriſts appears to conſiſt in the iron, which the latter conſider as a neceſſary part of the combination; by means of which they account for its difficult combuſtibility. Since plumbago does really contain iron, it may be conſidered as a compound of a ſimilar nature to the martial pyrites. Thus in the pyrites iron is united to ſul-

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* Scheele. See his Eſſays, Eng. Tranſ. Eſſay xiii.

† Acad. Par. 1785, page 132 et ſeq.

phur; which the phlogiſtian philoſophers aſſert to be a compound of vitriolic acid (or its baſe) and phlogiſton; while their opponents take the ſulphur to be a ſimple ſubſtance, capable of acidification by the addition of vital air: and ſo likewiſe plumbago is a compound of iron, united to another ſubſtance; which the phlogiſtians aſſert to be fixed air, combined with phlogiſton; at the ſame time that the other party, rejecting the inflammable principle, affirm that it is the ſimple acidifiable baſe, which will form fixed air when vital air is added to it. We ſee therefore that it is the explanation, and not the facts, which forms the object of contention.

PLUMBUM CORNEUM. A combination of calx of lead with marine acid. It is very ſparingly ſoluble in water, and is uſually produced by adding marine acid or common ſalt to a ſolution of lead in weak nitrous acid.

POLARITY. In the experiments of magnetiſm, it has been found that the attractive and repulſive forces exerted between pieces of iron or ſteel which have undergone the touch (ſee MAGNETISM), are governed by the poſition of certain parts of the iron or magnet called its poles. Bodies attracted or repelled by the power of electricity are alſo obſerved to turn one ſide, if at liberty, towards the body which acts upon them. From analogy it is concluded that a ſimilar modification obtains in the effect of the chemical affinities, and is in a great meaſure the cauſe of the ſymmetrical figures of minerals. See ATTRACTION, alſo CRYSTALLIZATION.

POLLEN. The fecundating powder of the ſtamina of vegetables. The prolific matter in the male part of plants is elaborated by the anthera; and as the organs of the plant do not admit of an actual intromiſſion of the male into the female, becauſe vegetables do not poſſeſs loco-motion, the fecundating ſeed is produced in the character of a powder, which the agitation of the air and other cauſes may carry off and precipitate upon the female organs. This fecundating powder has a ſmell reſembling that of the ſpermatic fluid of animals. It is uſually of a reſinous nature; that is to ſay, it is inflammable, and ſoluble in alkalis and ardent ſpirit. The wax of bees conſiſts of the pollen very little altered.

POMPHOLIX. The white calx which ſublimes during the combuſtion of zinc has been called by this name. It is better known by the name of flowers of zinc.

PONDEROUS EARTH. See EARTH PONDEROUS, alſo SPAR.

PONT MARLE. See MARLE.

PORCELAIN * is the moſt beautiful and the fineſt of all earthen wares. All earthen wares which are white and ſemi-tranſparent are generally called porcelains; but amongſt theſe ſo great differences may be obſerved, when they are examined chemically, that, notwithſtanding the ſimilarity of their external appearance, they cannot be conſidered as matters of the ſame kind. Theſe differences are ſo evident, that even perſons who are not connoiſſeurs in this way prefer much the porcelain of ſome countries to that of others.

As the ſeveral kinds of porcelain differ ſo much from each other, no general proceſs can be given for making it. We ought to confine ourſelves to deſcribe and conſider the manufacture of ſome particular porcelain, remarkable for its excellence and beauty. But this alſo is almoſt impracticable, becauſe in all the manufactories where it is made, both in France and other countries, the ingredients and method of preparation employed are carefully concealed. (See GLASS, p. 352.)

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* This article is taken chiefly from Macquer, Weigleb, and Lewis.

p. 352.) The exhibition of a general ſtatement of the principal operations will nevertheleſs be of value, not only to artiſts, who very often have no general views of the ſubjects they purſue, but to philoſophical men, who moſt frequently are the beſt improvers of manufactories.

The art of making porcelain is one of thoſe in which Europe has been excelled by oriental nations. The firſt porcelain that was ſeen in Europe was brought from Japan and China. The whiteneſs, tranſparency, fineneſs, neatneſs, elegance, and even the magnificence of this pottery, which ſoon became the ornament of ſumptuous tables, did not fail to excite the admiration and induſtry of Europeans. It would perhaps be a fruitleſs undertaking to inquire into the hiſtory of the ſeveral attempts made in Europe to imitate the original porcelain, as moſt of theſe are unknown, and would lead us too far from the ſubject. Macquer is of opinion, that the firſt European porcelains were made in Saxony and in France; and afterwards in England, Germany, and Italy. But as all theſe were different from the Japaneſe, ſo each of them had its peculiar character.

The illuſtrious Reaumur firſt attended to this object among the moderns, and communicated his reſearches in two Memoirs to the Academy of Sciences in 1727 and 1729. This great experimental philoſopher took the beſt method of arriving at a thorough knowledge of the ſubject; and although he was miſtaken in ſome points, and neglected to conſider ſome of the eſſential qualities requiſite to conſtitute good porcelain, he is nevertheleſs the firſt perſon who publiſhed any diſtinct notions upon the ſubject. He did not ſatisfy himſelf with conſidering the external appearance, the painting and gilding, which are only ornaments not eſſential to the porcelain, but he endeavoured to examine it internally: and having broken pieces of the Japaneſe, Saxon, and French porcelains, he examined the difference of their grains (which name is given to their internal ſtructure). The grain of the Japaneſe porcelain appeared to him to be fine, cloſe, compact, moderately ſmooth, and ſomewhat ſhining. The grain of the Saxon porcelain was found to be ſtill more compact, not granulous, ſmooth, ſhining like enamel. Laſtly, the porcelain of St. Cloud had a grain much leſs cloſe and fine than that of Japan, not, or but little ſhining, and reſembling the grain of ſugar.

From theſe firſt obſervations he perceived that porcelains differed conſiderably. That he might examine them further, he expoſed them to a violent heat. More eſſential differences than thoſe of the grain appeared upon this trial; for the Japaneſe porcelain was unaltered by the fire, and all the European were melted, as Reaumur ſays.

This eſſential difference betwixt the Japaneſe and European porcelains ſuggeſted to Reaumur a very ingenious thought, and in many reſpects true, concerning the nature of porcelain in general. As all porcelains ſomewhat reſemble glaſs in conſiſtence and tranſparency, though they are leſs compact and much leſs tranſparent, this philoſopher conſidered them as ſemi-vitrifications. Now every ſubſtance may appear, and may actually be in a ſemi-vitrified ſtate in two ways; for, firſt it may be entirely compoſed of vitrifiable or fuſible matters; and in this caſe, by expoſing it to the action of fire, it will be actually melted or vitrified, if the heat be ſufficiently ſtrong and long continued. But as this change is not made inſtantly, eſpecially when the heat is not very violent, and as it paſſes through different ſtages or degrees, which may be more eaſily obſerved as the heat is better managed; hence, by ſtopping in proper time the application of heat to porcelain made in this manner, we may obtain it in an intermediate ſtate betwixt thoſe of crude earths and of completely vitrified ſubſtances; and alſo poſſeſſed of the ſemi-tranſparency and of the other ſenſible qualities of porcelain. We know alſo, that if ſuch porcelain be expoſed to a ſtronger degree of fire, it will then be completely fuſed and entirely vitrified. But moſt of the European porcelains have this fuſibility, from which Reaumur concludes, that their compoſition is founded upon the above-mentioned principle.

In the ſecond place, a paſte of porcelain may be compoſed of fuſible and vitrifiable matter, mixed with a certain proportion of another matter which is abſolutely unfuſible in the fires of our furnaces. We may eaſily perceive, that if ſuch a mixture be expoſed to a heat ſufficient to melt entirely the vitrifiable ingredient, this matter will actually melt; but as it is intermixed with another matter which does not melt, and which conſequently preſerves its conſiſtency and opacity, the whole muſt form a compound partly opake and partly tranſparent; or rather a ſemi-tranſparent maſs; that is, a ſemi-vitrified ſubſtance, or porcelain, but of a kind very different from the former; for, as the fuſible part of this latter has produced all its effect, and as it has been as much fuſed as it can be during the baking of the porcelain, the compound may be expoſed a ſecond time to a more violent fire, without approaching nearer to a complete vitrification, or without departing from its ſtate of porcelain. But as oriental porcelain has preciſely theſe appearances and properties, Reaumur concludes with reaſon, that it is compoſed upon this principle; and he afterwards confirmed his opinion by undeniable facts.

Father Entrecolles, miſſionary at China, had ſent from thence a ſummary deſcription of the proceſs by which the inhabitants of that country make their porcelain; and alſo a ſmall quantity of the materials which they employ in its compoſition. He ſaid that the Chineſe compoſed their porcelain of two ingredients, one of which is a hard ſtone or rock, called by them petuntſe, which they carefully grind to a very fine powder; and the other, called by them kaolin, is a white earthy ſubſtance, which they mix intimately with the ground petuntſe. Reaumur examined both theſe matters; and having expoſed them ſeparately to a violent fire, he diſcovered that the petuntſe had fuſed without addition, and that the kaolin had given no ſign of fuſibility. He afterwards mixed theſe matters, and formed cakes of them, which by baking were converted into porcelain ſimilar to that of China. Reaumur eaſily found that the petuntſe of the Chineſe was a hard ſtone of the kind called vitrifiable, but much more fuſible than any of theſe which were known in Europe; and that the kaolin was a talky matter reduced to very fine powder. From that time he hoped to make a porcelain of the ſame kind as the Chineſe with materials found in France. Whether he could not find any materials equal to thoſe of China, particularly that material analogous to the petuntſe of the Chineſe, or becauſe other occupations prevented the continuance of his reſearches, we do not know; but we find from his ſecond Memoir upon porcelain, that he afterwards attempted to make an artificial petuntſe, by mixing our vitrifiable ſtones with ſalts capable of rendering them fuſible, or even by ſubſtituting for it glaſs ready formed, and by adding to theſe ſuch ſubſtances as he thought might be ſubſtituted for kaolin. But he probably found that he could not execute theſe intentions; for he did not reſume this ſubject from the year 1729 to 1739, when he gave a proceſs for converting common glaſs to a ſingular kind of porcelain, to which he has given his name, and of which we ſhall treat in the following article.

Although Reaumur has not entirely exhauſted this ſubject, he has ſurmounted many difficulties, and has given juſt notions concerning it: in a word, he has opened the road for all thoſe who afterwards engaged in this purſuit, and has therefore a right to ſhare the honour of the important diſcoveries which have been ſince made by others.

But as a perſon who firſt unravels ſo intricate and hidden a matter as the manufacture of porcelain, can ſcarcely diſcover every thing concerning his ſubject, ſo Reamur has been miſtaken, or rather miſled, in two important particulars, which Macquer points out. His firſt error concerns the Saxon porcelain, which he confounds with the other fuſible porcelains made in Europe. Macquer expreſſes his doubts whether formerly a porcelain was made in Saxony, compoſed entirely of fuſible or vitrifiable materials, the vitrification of which was ſtopped in proper time. Poſſibly this was the firſt kind of porcelain made in that country, and which Reaumur had examined. He is however certain that he has never ſeen any ſuch Saxon porcelain, and that all of that country which he had examined was capable of reſiſting the moſt violent fires without fuſion, as well at leaſt as thoſe of China and Japan. Reaumur might have been miſled by the appearance of the internal texture of this porcelain. For when a piece of it is broken, its internal ſurface does not appear granulous, but compact, uniform, ſmooth, ſhining, and much reſembling white enamel. But this appearance, ſo far from ſhewing that Saxon porcelain is a fuſed or vitrified ſubſtance, proves that it is not entirely compoſed of fuſible matters. All who have conſidered attentively this ſubject, know that the internal ſurface of the moſt fuſible porcelains is alſo the leaſt denſe and leaſt compact; the reaſon of which is, that no vitreous matter can be ſmooth and denſe internally, unleſs it has been completely fuſed. But if the denſity and ſhining appearance of the internal ſurface of the Saxon porcelain were only the effects of the fuſion of a vitreous matter, how could we conceive that veſſels formed of that matter ſhould have ſuſtained the neceſſary fuſion for giving this denſity and ſhining appearance, without having entirely loſt their ſhape? The impoſſibility of this is evident to every one who has been converſant in theſe matters, and in the fuſion of glaſs.

This quality of the Saxon porcelain muſt therefore proceed from another cauſe. It does indeed contain, as every porcelain does, particularly thoſe of China and Japan, a fuſible ſubſtance, which has been even completely fuſed during the baking. Its denſity alſo and its internal luſtre proceed chiefly from this fuſed matter; but we are alſo certain that it contains a large quantity of a ſubſtance abſolutely unfuſible, from which it receives its admirable whiteneſs, its firmneſs and ſolidity during the baking; in a word, which ſupplies the place of the oriental kaolin, and which has the property of contracting its dimenſions conſiderably while it incorporates with the fuſible ſubſtance. If it be ſubjected to the moſt deciſive trial, namely, the action of a violent fire, capable of melting every porcelain compoſed of fuſible matters alone, Macquer affirms, after many experiments, that it cannot be fuſed, unleſs by a fire capable of melting the beſt Japaneſe porcelain. The Saxon porcelain is therefore not to be confounded with thoſe which are vitreous and fuſible, but is in its kind as excellent as that of Japan, and perhaps ſuperior, as we ſhall ſee when we enumerate the qualities which conſtitute the excellence of porcelain. The ſubject of Reaumur's ſecond error, or, at leaſt, that which he has not ſufficiently explained, is the kaolin of China. According to him, this matter is a fine talky powder, from the mixture of which with petuntſe the oriental porcelain is formed. Poſſibly a very finely-ground talky ſubſtance mixed with petuntſe might form a porcelain ſimilar to the oriental; but perſons acquainted with the manufacture of any porcelain muſt perceive the impoſſibility

poſſibility of forming veſſels, unleſs the paſte of which they are made be ſo ductile and tenacious, that it may be worked upon a potter's lathe, or at leaſt that it may be moulded. But talks or any kinds of ſtones, however finely ground, cannot acquire the requiſite tenacity, which clays only, of all known earthy ſubſtances, poſſeſs. The Chineſe porcelain veſſels evidently appear to be turned upon the lathe, ſince they retain the marks of it: hence they muſt have been formed of a very tenacious paſte, and conſequently the kaolin is not a purely talky matter, but is mixed with clay; or elſe the petuntſe and kaolin are not, as Reaumur ſuppoſes, the only ingredients of the paſte of which Chineſe porcelain is formed, but a ſufficient quantity of ſome binding matter, unknown to father d'Entrecolles and Reaumur, muſt be alſo added.

Although, ſince Reaumur, no ſcientific perſon has written concerning porcelain, many have attempted to make it. Manufactures have been eſtabliſhed in almoſt all the ſtates of Europe. Beſides that of Saxony, which has been long eſtabliſhed, porcelain is alſo made at Vienna, at Frankendal, and lately in the neighbourhood of Berlin. All theſe German porcelains are ſimilar to the Saxon, and are made of materials of the ſame kind, although they differ ſomewhat from each other. England and Italy alſo have their porcelains, the chief of which were thoſe of Chelſea and of Naples. But porcelain is now made of a good quality in Staffordſhire, and many other parts of England. M. de la Condamine, in a journey into Italy, viſited a manufacture of porcelain eſtabliſhed at Florence by the Marquis de Ginori, then governor of Leghorn. M. de la Condamine obſerved particularly the large ſize of ſome pieces of this ware. He ſays he ſaw ſtatues and groupes half as large as nature, modelled from ſome of the fineſt antiques. The furnaces in which the porcelain was baked were conſtructed with much art, and lined with bricks made of the porcelain materials. The paſte of this porcelain is very beautiful; and from the grain of broken pieces of it, it appears to have all the qualities of the beſt Chineſe porcelain. A whiter glazing would be deſirable, which they might probably attain, if the Marquis Ginori had not determined to uſe thoſe materials only which were found in that country.

But in no ſtate of Europe have more effectual attempts been made to diſcover porcelain, or an earlier eſtabliſhment of manufactures, than in France. Before even Reaumur had publiſhed on this ſubject, porcelain was made at St. Cloud, and in the ſuburb of St. Antoine at Paris, which was of the vitreous and fuſible kind, but conſiderably beautiful. Since that time, conſiderable manufactures of it have been eſtabliſhed at Chantilly, at Villeroi, and at Orleans; the porcelains of which have a diſtinguiſhed merit. But certainly the admirable works produced in the royal manufacture at Sevres do moſt honour to France. This porcelain holds at preſent a diſtinguiſhed rank, from its ſhining white, its beautiful glazing, and coloured grounds, in which according to Macquer no porcelain has equalled it. The magnificence of the gilding, the regularity and elegance of its forms, ſurpaſs every thing of the kind. In the painting and ſculpture much genius and talents are diſplayed. Laſtly, as all the operations of this great eſtabliſhment were directed by men of known capacity, aſſiſted by philoſophical and chemical reſearches, this manufacture in Macquer's time was upon the point of producing porcelain capable of emulating or equalling the moſt perfect and moſt ſolid works of this kind.

We muſt carefully diſtinguiſh the qualities which only contribute to beauty and external appearance, from the intrinſic and eſſential properties in which the goodneſs and ſolidity of porcelain conſiſt. All perſons who have made experiments in this way have ſoon diſcovered the poſſibility of making compounds very white, beautifully ſemi-tranſparent, and covered with a ſhining glazing, but which cannot be worked for want of tenacity, are not ſufficiently compact, are eſſentially fuſible, are ſubject to break by ſudden application of heat and cold; and laſtly, the glazing of which cracks, becomes rough, and conſequently loſes its luſtre by uſe, becauſe it is too ſoft.

On the other ſide, we ſhall alſo find it not difficult to compoſe very tenacious paſtes, which ſhall be capable of being eaſily worked and well baked, which in the baking ſhall acquire the deſirable hardneſs and denſity, which are unfuſible, and capable of ſuſtaining very well the ſudden change of heat and cold; and in a word, which ſhall have the qualities of the moſt excellent porcelain, excepting whiteneſs and beauty. We ſhall ſoon ſee that the materials fit for the compoſition of ſuch porcelains may be found abundantly in every country. The only difficulty then in this inquiry concerning porcelain is, to unite beauty and goodneſs in one compoſition.

Macquer firſt remarked, that before we had any knowledge of oriental porcelain, and from time immemorial, porcelain was made in Europe equal to it in goodneſs and in eſſential qualities, and was univerſally uſed, and even ſold very cheap. For thoſe potteries called ſtone-ware are not of modern invention, and have all the eſſential qualities of the beſt Japaneſe. If we except whiteneſs, on which alone the ſemi-tranſparency depends, and compare all the properties of Japaneſe porcelain with thoſe of our ſtone-ware, no difference can be found betwixt them. The ſame grain appears internally in both; the ſame ſound is produced by ſtriking them when properly ſuſpended; the ſame denſity, the ſame hardneſs, by which they ſtrike fire with ſteel; the ſame faculty of ſuſtaining the heat of boiling liquors without breaking, and the ſame unfuſibility in fire, are obſervable. Laſtly, if the earths of which ſtone-ware is made were free from heterogeneous colouring matters, which prevent their whiteneſs and ſemi-tranſparency; if veſſels were carefully formed; if all the proper attentions were given; and if theſe veſſels were covered over with a fine glazing; they would be as perfect porcelain as that of Japan. The moſt perfect porcelain, therefore, is nothing elſe than a fine white ſtone-ware.

The French ſtone-ware, or potteries de grais, is formed of a whitiſh clay, in which a good deal of fine white ſandy particles is intermixed. The Engliſh ſtone-ware is compoſed of tobacco-pipe clay and ground flints. This ware, when ſufficiently burnt, has, as well as the French, the qualities of porcelain which Macquer calls eſſential, namely ſtrength, hardneſs, the property of ſuſtaining the heat of boiling water, and unfuſibility. See POTTERY.

Earths of this kind were thought to be more rare in Europe than in Japan and China. And probably alſo the want of a knowledge where to find theſe earths was the cauſe that the firſt makers of porcelain confined themſelves to an external imitation, by employing nothing but vitrifiable matters with fuſible ſalts and a ſmall quantity of white earth, from which fuſible and vitreous porcelains were compoſed, which might be called falſe porcelains. But things are much changed ſince theſe firſt attempts. Beſides the diſcoveries of the Count de Lauraguais and of Mr. Guettard, genuine white porcelains have been made a long time ago in Germany, eſpecially in Saxony and at Frankendal.

Theſe porcelains are not inferior in any reſpect to the oriental; they are even much ſuperior in beauty and whiteneſs to the modern oriental porcelain, which has much degenerated in theſe reſpects: they ſeem even to excel the oriental in the moſt valuable quality of porcelain, namely, the property of ſuſtaining the ſudden change of heat and cold. We cannot judge of the quality of porcelain by a ſlight trial: for ſo many circumſtances concur to make a piece of porcelain capable or incapable of ſuſtaining the ſudden application of heat and cold, that if at the ſame time boiling water be poured into two veſſels, one of which is good porcelain and the other bad, the former may poſſibly break, and the latter remain entire: the only true method of diſcovering good porcelain in this reſpect is, to examine ſeveral pieces of it which are daily uſed—for inſtance, a ſet of coffee cups. But Macquer ſays, he has obſerved that in many ſuch pieces of oriental porcelain, which have been long and daily uſed, cracks in the direction of their height may be always perceived, which are never ſeen in the good European porcelains.

Every one talks of porcelain, and yet few are connoiſſeurs in it. None can be conſidered as ſuch but thoſe who have long made it an object of their inquiries. That the ancient Japaneſe porcelain is the moſt perfect, is a general opinion. This porcelain is indeed very beautiful, and we muſt alſo acknowledge that its quality is excellent. It has been our model, and has long been the object of our admiration and emulation; but which we have never been able to equal, and which many perſons believe never can be equalled. Some perſons even decry the Saxon porcelain for a quality which really gives it a ſuperiority to the Japaneſe, namely, the greater ſmoothneſs, luſtre, and leſs granulous appearance of its internal ſurface than the oriental. The reſemblance of this ſurface to that of glaſs has evidently ſuggeſted this notion; and it would be well founded, if the denſity and luſtre of this porcelain proceeded only from a fuſible and vitreous quality: but as they do not, and as this porcelain is as fixed and as unfuſible as the Japaneſe, its denſity, ſo far from being a fault, is a valuable quality. For we muſt allow, that of porcelains equal in other reſpects, thoſe are beſt which are moſt firm and compact. Hence, the interior ſubſtance of the Japaneſe porcelain is eſteemed for its greater denſity, compactneſs and luſtre, beyond our vitreous or fritt porcelains, becauſe theſe qualities indicate greater coheſion, and more intimate incorporation of its parts. For the ſame reaſon alſo, the ſuperior denſity of the Saxon porcelain ought to give it the preference to the Japaneſe. Beſides, nothing would be eaſier than to give the Saxon porcelain the granulous texture of the Japaneſe, by mixing with the paſte a certain quantity of ſand. But the perſons who perfected that manufacture were certainly ſenſible, that ſuch a conformity to the Japaneſe porcelain would leſſen the merit of theirs. For we know that, in general, porcelains are better in proportion as they contain a larger proportion of clay or earth, and leſs of ſand, flints, or other matters of that kind.

The baſis of the porcelains which Macquer calls fuſible, vitreous, or falſe porcelains, is called by artiſts a fritt. It is nothing elſe than a mixture of ſand or of powdered flints, with ſalts capable of diſpoſing them to fuſion, and of giving them a great whiteneſs by means of a ſufficient heat. This fritt is to be then mixed with as much, and no more, of a white tenacious earth, of an argillaceous or marly nature, than is ſufficient to make it capable of being worked upon the wheel. The whole mixture is to be well ground together in a mill, and made into a paſte, which is to be formed, either upon the wheel or in moulds, into pieces of ſuch forms as are required.

Each of theſe pieces when dry is to be put into a caſe made of earthen ware. Theſe caſes are called by Engliſh potters, *ſeggars*, which is a corruption of the words *ſafe guard*. They are generally formed of coarſer clays, but which muſt alſo be capable of ſuſtaining the heat required without fuſion. By means of theſe caſes, the contained porcelain is preſerved from the ſmoke of the burning fuel. The whiteneſs of the porcelain depends much on their compactneſs of texture, by which the ſmoke is excluded, and on the purity of the clay of which they are made. Theſe caſes are to be ranged in piles one upon another, in a furnace or kiln, which is to be filled with them to the roof. The furnaces are chambers or cavities of various forms and ſizes, and are ſo diſpoſed that their fire-place is placed on the outſide, oppoſite to one or more openings which communicate within the furnace. The flame of the fuel is drawn within the furnace, the air of which rarefying determines a current of air from without inwards, as in all furnaces. At firſt a very little fire is made, that the furnace may be heated gradually, and is to be increaſed more and more, till the porcelain is baked, that is, till it has acquired its proper hardneſs and tranſparency; which is known by taking out of the furnace from time to time, and examining, ſmall pieces of porcelain, placed for that purpoſe in caſes which have lateral openings. When theſe pieces ſhew that the porcelain is ſufficiently baked, the fire is no longer to be ſupplied with fuel, the furnace is to be cooled, and the porcelain taken out, which in this ſtate reſembles white marble not having a ſhining ſurface. This is afterwards to be given by covering them with a vitreous compoſition, called the glazing.

The porcelain when baked and not glazed is called biſcuit, and is more or leſs beautiful according to the nature of its compoſition.

As no imitation of ſculpture in porcelain can preſerve all the delicacy of its workmanſhip when covered with a glazing; and as ſculptors avoid poliſhing their marble figures, becauſe the luſtre of the poliſh is diſadvantageous; therefore, in ſuperior manufactures, all figures, or little ſtatues, and even ſome ornamental vaſes, are left in ſtate of biſcuit. The other pieces of porcelain are to be glazed in the following manner:

A glaſs is firſt to be compoſed ſuited to the nature of the porcelain to which it is to be applied, for every glaſs is not fit for this purpoſe. We frequently find that a glaſs which makes a fine glazing for one porcelain, ſhall make a very bad glazing for another porcelain, ſhall crack in many places, ſhall have no luſtre, or ſhall contain bubbles. The glazing then muſt be appropriated to each porcelain, that is, to the hardneſs and denſity of the ware, and to the ingredients of its compoſition, &c. Much appears to depend on the glaze, and the body of the ware poſſeſſing the property of equally expanding by increaſe of temperature: if they differ in this reſpect, the glaze muſt infallibly crack during the cooling from the furnace.

Theſe glazings are prepared by previouſly fuſing together all the ſubſtances of which they conſiſt, ſo as to form vitreous maſſes. Theſe maſſes are to be ground very finely in a mill. This vitreous powder is to be mixed with a ſufficient quantity of water, or other proper liquor, ſo that the mixture ſhall have the conſiſtence of cream of milk. The pieces of porcelain are to be covered with a thin ſtratum of this matter, and when very dry they are to be again put into the furnace in the ſame manner as before, for the forming of the biſcuit, and to be continued there till the glazing be well fuſed. The neceſſary degree of fire for fuſing the glazing is much leſs than for baking the paſte.

The pieces of porcelain which are intended to remain white are now finiſhed; but thoſe which are to be painted and gilded muſt undergo further operations.

The colours to be applied are the ſame as thoſe uſed for enamel painting. They all conſiſt of metallic calxes bruiſed and incorporated with a very fuſible glaſs. Crocus of iron furniſhes a red colour. Caſſius's precipitate of gold makes the purple and violet; copper calcined by acids and precipitated by an alkali gives a fine green; zaffic makes the blue; earths ſlightly ferruginous produce a yellow; and, laſtly, brown and black colours are produced by manganeſe or by calcined iron, together with a deep blue of zaffic. Theſe colours being ground with gum water, or with oil of ſpike, are to be employed for the painting of the porcelain with deſigns of flowers and other figures. For gilding, a powder or calx of gold is to be applied in the ſame manner as the coloured enamels. The painted and gilded porcelains are to be then expoſed to a fire capable of fuſing the glaſs with which the metallic colours are mixed. Thus the colours are made to adhere, and at the ſame time acquire a gloſs equal to that of the glazing. The gold alone has not then a ſhining appearance, which muſt be afterwards given to it by burniſhing with a blood-ſtone.

The operations for the unfuſible porcelains, and alſo for ſuch as are of the nature of ſtone-ware, are ſomewhat more ſimple. The ſands and ſtones which enter into their compoſition are to be ground in a mill: the earths or clays are to be waſhed: the materials are to be well mixed, and formed into a paſte: the pieces are firſt rudely formed upon a potter's wheel; and when dry or half dry, they are turned again upon the wheel, or in a lathe or other engine, and their form is made more perfect: they are then placed in the furnace, not to bake them, but only to apply a ſufficient heat to give them ſuch a ſolidity that they may be handled without breaking, and may receive the glazing. As the pieces of porcelain after this ſlight heat are very dry, they imbibe water readily. This diſpoſition aſſiſts the application of the glazing. The vitrifiable or vitrified matter of this glazing, which has been previouſly ground in a mill, is to be mixed with ſuch a quantity of water, that the liquor ſhall have the conſiſtence of milk. The pieces of porcelain are haſtily dipped in this liquor, the water of which they imbibe, and thus on their ſurface is left an uniform covering of the glazing materials. This covering, which ought to be very thin, will very ſoon become ſo dry, that it cannot ſtick to the fingers when the pieces are handled.

The pieces of the porcelain are then put into the furnace to be perfectly baked. The heat is to be raiſed to ſuch a height, that all within the furnace ſhall be white, and the caſes ſhall be undiſtinguiſhable from the flame. When, by taking out ſmall pieces, the porcelain is known to be ſufficiently baked, the fire is diſcontinued, and the furnace cooled. If the baking has been well performed, the pieces of porcelain will be found by this ſingle operation to be rendered compact, ſonorous, cloſe-grained, moderately gloſſy, and covered externally with a fine glazing. The painting and gilding of this porcelain are to be executed in a manner ſimilar to that already deſcribed. For the various compoſitions of glazes and enamels, ſee POTTERY.

PORCELAIN OF REAUMUR. Reaumur having made many experiments to diſcover the nature of the materials which enter into the compoſition of the oriental porcelain, and having aſcertained that all porcelain is an intermediate ſubſtance betwixt an earth and glaſs, very ingeniouſly thought of reducing glaſs ready made to the ſtate of porcelain, by reverſing the effect of the vitrification, or partly unvitrifying it: hence this kind of ware has been called porcelain unvitrified. Reaumur gave the quality of porcelain to glaſs; that is, he rendered glaſs of a milky colour, ſemi-tranſparent, ſo hard as to ſtrike fire with ſteel, unfuſible, and of a fibrous grain, by means of cementation. The proceſs which he publiſhed is not difficult. Common glaſs, ſuch as that of which wine-bottles are made, ſucceeds beſt. The glaſs veſſel which is to be converted into porcelain is to be incloſed in a baked earthen caſe or ſeggar. The veſſel and caſe are to be filled with a cement compoſed of equal parts of ſand and powdered gypſum or plaſter; and the whole is to be put into a potter's kiln, and to remain there during the baking of common earthen ware; after which the glaſs veſſel will be found transformed into ſuch a matter as has been deſcribed.

This kind of porcelain has not a very white colour, particularly on its ſurface; but for ſome purpoſes it may be uſeful, eſpecially for chemical veſſels. Reaumur has not explained how this transformation is effected. Macquer imagined that the vitriolic acid of the gypſum quits its baſis of calcareous earth, and unites with the alkaline ſalt and ſaline earth of the glaſs, with which it forms a kind of ſalt or ſelenites, different from the calcareous ſelenites, by the interpoſition of which matter, the glaſs acquires the qualities of porcelain.

Reaumur ſays, that glaſs thus rendered opake, white, unfuſible, and hard, is inferior in beauty to the oriental porcelain; but that in utility and every eſſential quality of porcelain, it is equal to any, and even ſuperior in the property of ſuſtaining alterations of heat and cold.

The character given by Reaumur of this porcelain induced Dr. Lewis (who had alſo obſerved the changes produced upon glaſs retorts expoſed to violent heat in a ſand-bath) to make further experiments on this matter, an account of which he has publiſhed in the Philoſophical Commerce of Arts.

From Dr. Lewis's experiments we find the following reſults: 1. Green glaſs cemented with white ſand received no change in a heat below ignition. In a low red-heat the change proceeded exceeding ſlowly; and in a ſtrong red-heat, approaching to whiteneſs, the thickeſt pieces of glaſs bottles were thoroughly converted in the ſpace of three hours. 2. The glaſs ſuffered the following progreſſion of changes by continued heat: firſt, its ſurface became blue, its tranſparency was diminiſhed, and a yellowiſh hue was obſervable when it was held between the eye and the light. Afterwards it was changed a little way on both ſides into a white ſubſtance, externally ſtill blueiſh; and as this change advanced ſtill farther and farther within the glaſs, the colour of the vitreous part in the middle approached nearer to yellow: the white coat was of a fine fibrous texture, and the fibres were diſpoſed nearly parallel to one another, and tranſverſe to the thickneſs of the piece: by degrees the glaſs became throughout white and fibrous, the external blueiſhneſs at the ſame time going off, and being ſucceeded by a dull whitiſh or dun colour: by a ſtill longer continuance in the fire, the fibres were changed gradually from the external to the internal part, and converted into grains; and the texture then was not unlike that of common porcelain. The grains, at firſt fine, and ſomewhat gloſſy, appeared afterwards larger and duller, and at length the ſubſtance of the glaſs became porous and friable, like a maſs of white ſand ſlightly coherent. 3. Concerning the qualities of the converted glaſs Dr. Lewis obſerves, that the whiteneſs of the internal part was not inferior to that of porcelain, but that its ſurface was the leaſt beautiful, that the thick pieces were quite opake, and that ſeveral thin pieces were ſemi-tranſparent: that while it remained in a fibrous ſtate, its hardneſs became greater than that of glaſs, or of the common kinds of porcelain; it was capable of ſuſtaining ſudden changes of heat and cold better than any porcelain ; and in a moderate white heat, it was fuſible into a ſubſtance not fibrous, but vitreous and ſmooth, like white enamel : that when its texture had become coarſely granulated, it was now much ſofter and unfuſible : and laſtly, that when ſome coarſely granulated unfuſible pieces, which with the combination of a moderate heat would have become porous and friable, were ſuddenly expoſed to an intenſe fire, they were rendered remarkably more compact than before ; the ſolidity of ſome of them being ſuperior to that of any other ware. 4. No difference appeared in the internal colour, hardneſs, texture, or the regular ſucceſſion of changes, from the uſe of different cementing ſubſtances ; though in external appearances the differences were conſiderable. All the pieces which had been ſurrounded with charcoal or with ſoot, were externally of a deep black colour, which did not diſappear by expoſure to a ſtrong fire during an hour, with free acceſs of air. Coloured clays and ſands communicated different ſhades of a brown colour ; and white earths gave whitiſh, grayiſh, or browniſh tinges. White ſand, calcined flints, and gypſum, gave in general the greateſt whiteneſs, and tobacco-pipe clay the greateſt gloſſineſs and brightneſs. 5. Glaſſes compoſed of earths without alkaline ſalt, glaſs of lead, flint-glaſs, crown-glaſs, looking-glaſs plates, a glaſs prepared with calcined flints and a fixed alkaline ſalt, and even green glaſs which had been fuſed together with a ninth part of alkaline ſalt, ſuffered none of the above alterations by cementation. Green bottle-glaſs and common window-glaſs were moſt ſuſceptible of theſe alterations. 6. The changes produced by cementation could not proceed from any abſorption of matter from the cementing ſubſtance; becauſe no increaſe of weight was given, and becauſe the ſame changes were produced upon a piece of glaſs merely by heat, without any cementing ſubſtance.

Dr. Lewis in his reflections on this ſubject refers the change to a loſs of part of the alkali of the glaſs. The weight of the fibrous porcelain is not perceptibly different from that of the glaſs itſelf; but he obſerves, that the alkali which may exſude is attached to the outer ſurface ; and in the latter ſtages of the proceſs, it evidently cauſes an agglutination of the ſand in which the glaſs may be bedded. M. Delaval, who has made many experiments on this object, ſhewed me a maſs of ſand concreted in the form of the neck of a bottle, out of which he had poured the ſand of the glaſs itſelf reduced to perfect grains by the heat. It ſeems probable in this inſtance, that the ſand of cementation had a greater affinity to the alkali than that of the glaſs itſelf.

PORPHYRY. Porphyrites. The porfido of the Italians. Cronſtedt enumerates five kinds: 1. Green, with a light green felt-ſpar. *Serpentino verde antico.* It is ſaid to have been brought from Egypt to Rome, from which laſt place the ſpecimens now come. 2. Deep red with white felt-ſpar from Italy and Egern in Norway. 3. Black with white and red felt-ſpar from Klitten in the pariſh of Elfdalen in Norway. 4. Reddiſh brown with light red and white felt-ſpar ; and 5. Dark gray with white grains of felt-ſpar. The dark red porphyry has been moſt frequently employed for ornaments and in building.

De Sauſſure and Kirwan, quoted by Magellan, both reckon under the name of porphyry or porfido of the Italians, ſuch ſtones as contain either felt-ſpar, quartz, ſhoerl, mica, with other ſpecies of ſtone of a cryſtalline form in a ſiliceous or even calcareous ground. Ferber, in his ſixteenth letter from Italy, deſcribes twenty varieties of porfido. But in general it is diſtinguiſhed by the colour of its ground, that is, either red, purple, gray, green, or black. When the ground is of jaſper the porfido is very hard. The red commonly contains felt-ſpar in ſmall white dots or ſpecks, and often together with theſe black ſpots of ſhoerl. The green is either a jaſper or ſhoerl with ſpots of quartz. It is often magnetic. Sometimes a porphyry of one colour contains a fragment of porphyry of another colour. Thoſe which have chert for their ground are fuſible without addition. The calcareous porphyry conſiſts of quartz, felt-ſpar, and mica, in ſeparate grains united by a calcareous cement. And the micaceous porphyry conſiſts of a greeniſh-gray micaceous ground, in which red felt-ſpar and greeniſh ſoap-rock are contained.

PORTLAND STONE. A compact ſand-ſtone from the Iſle of Portland. The cement is calcareous.

POTASH. It is univerſally known * that the vegetable fixed alkali may be extracted in greater or leſs quantity from the roots of almoſt all vegetables, and it is now well eſtabliſhed, that it pre-exiſts in vegetables before combuſtion, not indeed in a ſeparate uncombined ſtate, but united partly with the vitriolic and marine acids, and ſometimes the nitrous, but generally, and for the greater part, with a vegetable acid and oil, with which it forms eſſential ſalts, as they are termed. Theſe vegetable acids and oils are decompoſed during combuſtion, and thus the alkaline part is ſet free. But the vitriolic acid by contact with inflamed matter, is converted into ſulphur, part of which unites to the diſengaged alkali, which protects it from combuſtion, and forms what is called liver of ſulphur; a product formed in moſt aſhes, eſpecially when the air has not had free acceſs to them during combuſtion.

As alkaline ſalts are of great importance in the ſeveral arts, the proportion of aſhes afforded by different vegetables, and that of alkali by each vegetable has of late been accurately attended to. Kirwan has therefore preſented the beſt authenticated reſults of the experiments made with this view.

One thouſand lbs.	*lbs. of aſhes.*	*lbs. of ſalt.*	
Stalks of Turkey wheat or mais	88,6	17,5	
Sun-flowers	57,2	20,	
Vine-branches	34,	5,5	
Box	29,	2,26	
Sallow	28,	2,85	
Elm	23,5	3,9	
Oak	13,5	1,5	
Aſpen	12,2	0,74	
Beech	5,8	1,27	
Fir	3,4	0,45	
Fern in Auguſt	36,46	4,25	Home
Wormwood	97,44	73,	Wiegleb
Fumitory	219,	79,	Idem.

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* This article is taken from Kirwan's excellent and uſeful paper on the alkalis in the Iriſh Tranſactions for 1789.

Table of the ſaline product of one thouſand lbs. of aſhes of the following vegetables.

		Saline products.
Stalks of Turkey wheat or mais		198 lbs.
Stalks of Sun-flower	—	349
Vine branches	—	162,6
Elm —	—	166
Box —	—	78
Sallow —	—	102
Oak —	—	111
Aſpen —	—	61
Beach —	—	219
Fir —	—	132
Fern cut in Auguſt	—	116 or 125 according to Wildenheim
Wormwood	—	748
Fumitory	—	360
Heath —	—	115 Wildenheim.

On theſe tables Kirwan makes the following remarks:

1. That in general, weeds yield more aſhes, and their aſhes much more ſalt, than woods; and that conſequently, as to ſalts of the vegetable alkali kind, as pot-aſh, pearl-aſh, caſhup, &c. neither America, Trieſte, nor the northern countries have any advantage over us (Ireland).

2. That of all weeds, fumitory produces moſt ſalt, and next to it wormwood. But if we attend only to the quantity of ſalt in a given weight of aſhes, the aſhes of wormwood contain moſt. Trifolium fibrinum alſo produces more aſhes and ſalt than fern.

Moſt of the experiments on woods were made in France by order of government, under the inſpection of the overſeers of the ſalt-petre works; yet are to be read with caution by thoſe who attend to the quantity of alkali with reſpect to bleachers. For as tartar vitriolate, a ſalt uſeleſs to bleachers, is as ſerviceable to the makers of ſalt-petre as alkaline ſalts*, they have conſtantly confounded one with the other; but the experiments made on weeds were inſtituted by perſons who carefully diſcriminated theſe ſalts. One hundred grains of the ſalt of wormwood contain but ſix of the tartar vitriolate, and one hundred grains of the ſalt of fumitory contain fifteen. All alkaline ſalts, unleſs mixed with lime, contain alſo one fifth at leaſt of fixed air, which produces no other effect in bleaching than that of reſtraining their activity.

The proceſs for obtaining pot and pearl aſh is given by Kirwan, as follows:

1. The weeds ſhould be cut juſt before they feed, then ſpread, well dried, and gathered clean.

2. They ſhould be burned within doors on a grate, and the aſhes laid in a cheſt as faſt as they are produced. If any charcoal be viſible, it ſhould be picked out, and thrown back into the fire. If the weeds be moiſt, much coal will be found. A cloſe ſmothered fire, which has been recommended by ſome, is very prejudicial.

3. They ſhould be lixiviated with twelve times their weight of boiling water.

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* Much of the nitre obtained by elixation of the nitre beds has a calcareous baſis. Tartar vitriolate will change this into priſmatic nitre by double affinity. For the alkali unites with the nitrous acid, which gives its calcareous baſe to the vitriolic. N.

A drop of the ſolution of corroſive ſublimate will immediately diſcover when the water ceaſes to take up any more alkali. The earthy matter that remains is ſaid to be a good manure for clayey ſoils.

4. The ley thus formed ſhould be evaporated to dryneſs in iron pans. Two or three at leaſt of theſe ſhould be uſed, and the ley, as faſt as it is concreted, paſſed from the one to the other. Thus, much time is ſaved, as weak leys evaporate more quickly than the ſtronger. The ſalt thus procured is of a dark colour, and contains much extractive matter, and being formed in iron pots is called pot-aſh.

5. This ſalt ſhould then be carried to a reverberatory furnace, in which the extractive matter is burnt off, and much of the water diſſipated: hence it generally loſes from ten to fifteen per cent. of its weight. Particular care ſhould be taken to prevent its melting, as the extractive matter would not then be perfectly conſumed, and the alkali would form ſuch an union with the earthy parts as could not eaſily be diſſolved. Kirwan adds this caution, becauſe Dr. Lewis and Mr. Doſſie have inadvertently directed the contrary. This ſalt thus refined is called pearl-aſh, and muſt be the ſame as the Dantzic pearl-aſh.

The French call the refined aſh *potaſſe*, and the unrefined *ſalin*. Kirwan remarks, that the alkali manufactured in the above-mentioned manner may not be ſufficiently cauſtic for the earlier operations of bleaching; but by the addition of half a pound of quick-lime to every hundred of the ſalt, or ten pounds for every ton, it will be rendered ſufficiently ſharp. There is no danger that any of the lime will remain in the ley; but if any ſhould, it will immediately be diſcovered and depoſited by the addition of a little of the unmixed ley.

For the moſt œconomical conſtruction of a laboratory and furnaces for the above operations, Kirwan refers to the deſcription given in a French tract called *L'Art de fabriquer le Salin et la Potaſſe*; which I have not ſeen. And he adds, that it would be no inconſiderable advantage to perform the evaporation by a fire made of vegetables, whoſe aſhes might afterwards be employed. Pearl-aſh, as he alſo remarks, is frequently tinged green or blue, not from any union of the ſalt with phlogiſton, as was formerly imagined, but from mangane ſe, which Scheele has ſhewn to exiſt in the aſhes of moſt vegetables. When the alkali is calcined without melting, it proves perfectly white, like the Dantzic pearl-aſh.

POT-STONE. See Lapis Ollaris.

POTTER's LEAD ORE. The galena or combination of lead and ſulphur.

POTTERY. * The art of making pottery is intimately connected with chemiſtry, not only from the great uſe made of earthen veſſels by chemiſts, but alſo becauſe all the proceſſes of this art, and the means of perfecting it, are dependent on chemiſtry. We muſt however acknowledge, that although chemiſts have the greateſt intereſt to procure good crucibles and other earthen veſſels, this art has been left almoſt entirely to the potter. Mr. Pott is the firſt who attended to this object. Beſides many experiments ſtated in his Lithogeognoſia, from which much inſtruction may be received relating to the perfection of chemical veſſels, he has written a treatiſe expreſsly on this ſubject, in which he gives many compoſitions for crucibles, the chief of which ſhall be mentioned in this article.

All kinds of pottery are in general made of clays or argillaceous earths, becauſe theſe earths are capable of being kneaded, and eaſily receiving any form, and of acquiring much ſolidity and hardneſs by expoſure to fire. But clays differ much in the effects produced upon them by fire. Some clays which are of the pureſt kind reſiſt the moſt violent fire without receiving any other change than a conſiderable hardneſs; but ſtill they are not rendered ſo hard and compact as other clays. A ſecond kind of clays by expoſure to violent heat acquires a hardneſs equal to that of flints, and a texture compact and gloſſy, like that of good porcelain; but they are nevertheleſs unfuſible by the moſt violent heat. Theſe qualities are occaſioned by ſome fuſible materials being mixed with them, as ſand, chalk, gypſum, or ferruginous earth, which are in too ſmall a quantity to effect a complete, but only a beginning or partial fuſion. Laſtly, a third kind of clays is firſt hardened by fire, and afterwards completely fuſed. This laſt kind of clays evidently contains the largeſt quantity of the fuſible matters above mentioned.

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* The general part of this article is from Macquer.

From the properties of theſe three principal clays it may be concluded, that from clays alone three principal kinds of pottery may be produced. With the firſt kind of clay, pots or crucibles may be formed capable of ſuſtaining the moſt violent fire without fuſion, of containing melted metals, and even hard glaſſes not too fluid; but which, from want of ſufficient compactneſs, are incapable of containing during a long time in fuſion very fuſible ſubſtances, ſuch as nitre, glaſs of lead, glaſſes containing much arſenic, &c. by which ſubſtances their pores are pervaded. Theſe clays are employed advantageouſly for the formation of large pots or crucibles uſed in glaſs-houſes for containing hard glaſs, as bottle-glaſs.

With clays of the ſecond kind may be made crucibles and other potteries, commonly called ſtone-ware. Potteries made with theſe earths, when ſufficiently baked, are very ſonorous, ſo hard as to ſtrike fire with ſteel, capable of containing all liquids, of which the former kind, from their poroſity, are incapable, and even reſiſt the action of nitre, glaſs of lead, and other fluxes, when the earth of which they are formed is of good quality: but their hardneſs and denſity, which prevent their ſudden expanſion and contraction, by the haſty application of heat and cold, make them liable to break in all operations where they are ſuddenly expoſed to heat or to cold, as for inſtance, in a furnace through which a ſtrong current of air paſſes. If this kind of pottery had not this inconvenience, it would be the beſt and moſt perfect for the purpoſes of ordinary life and chemiſtry. Notwithſtanding this inconvenience, it is the only pottery that is applicable on many occaſions; but then all poſſible care muſt be taken to prevent its breaking, by a very gradual application of heat and cold, and by protecting it from currents of cold air.

With the fuſible clays may be made many kinds of veſſels, which are cheap, as they require little fire to bake them; for all this kind of pottery is but ſlightly baked; whence its texture is coarſe and porous. Some utenſils are made of this pottery without glazing, as foot-ſtoves, &c. But in general they are covered with a glazing, without which, water or other liquids would paſs through their pores. Some of this pottery, which is finiſhed with more care, is covered with a white enamel, which makes it very neat and like porcelain. This is called DELFT WARE, which ſee. Other coarſer potteries of this kind are glazed with glaſs of lead mixed with metallic calxes, or fuſible coloured earths; from which they receive various colours. This is the ordinary pottery.

A fine kind of pottery is made of white clays, or of ſuch as whiten in the fire, the ſurface of which is vitrified by throwing into the furnace, when the ware is ſufficiently baked, ſome common ſalt and ſalt-petre. This pottery is called Engliſh ware on the continent, becauſe the firſt and beſt was made in England. It is white, fine, well baked, and has ſome ſmall degree of tranſparency when thin; ſo that it is intermediate betwixt porcelain and common ſtone-ware, and may therefore be called a ſemi-porcelain.

Keir affirms, that he has never ſeen any Engliſh ſtone-ware, that had the ſemi-tranſparency and whiteneſs mentioned by Macquer. As the Engliſh ſtone-ware is compoſed of tobacco-pipe clay and ground-flints, both which ſubſtances are perfectly unfuſible, ſingly or jointly, it cannot poſſeſs any degree of tranſparency. The uſe of the flints is to give ſtrength to the ware, ſo that it ſhall preſerve its form during the baking: whereas veſſels made of clay alone, though unfuſible by fire, and capable of acquiring, by having been expoſed to an intenſe heat, the hardneſs of the beſt porcelain; yet while they are hot and ſoft, they ſink by their own weight, ſo as to loſe the form given them. The proceſs of manufacturing this ſtone-ware, according to Dr. Watſon, is as follows:

Tobacco-pipe clay from Dorſetſhire is beat much in water: by this proceſs, the finer parts of the clay remain ſuſpended in the water, whilſt the coarſer ſand and other impurities fall to the bottom. The thick liquid, conſiſting of water and the finer parts of the clay, is farther purified by paſſing it through hair and lawn ſieves of different degrees of fineneſs. After this, the liquid is mixed (in various proportions for various wares) with another liquor, of as nearly as may be the ſame denſity, and conſiſting of flints calcined, ground and ſuſpended in water. The mixture is then dried in a kiln; and being afterwards beaten to a proper temper, it becomes fit for being formed at the wheel into diſhes, plates, bowls, &c. When this ware is to be put into the furnace to be baked, the ſeveral pieces of it are placed in the caſes made of clay, called ſeggars, which are piled one upon another, in the dome of the furnace: a fire is then lighted; and when the ware is brought to a proper temper, which happens in about 48 hours, it is glazed by common ſalt. The ſalt is thrown into the furnace, through holes in the upper part of it, by the heat of which it is inſtantly converted into a thick vapour; which circulating through the furnace, enters the ſeggar through holes made in its ſide (the top being covered to prevent the ſalt from falling on the ware), and attaching itſelf to the ſurface of the ware, it forms that vitreous coat upon the ſurface, which is called its glaze.

This curious method of glazing earthen ware by the vapour of common ſalt was introduced into England by two Dutchmen, near a century ago. It appears to be produced by a combination of the alkali with the ſiliceous earth or ſand of the clay.

The yellow or Queen's ware is made of the ſame materials as the flint-ware; but the proportion in which the materials are mixed is not the ſame, nor is the ware glazed in the ſame way. The flint-ware is generally made of four meaſures of liquid flint, and of eighteen of liquid clay; the yellow ware has a greater proportion of clay in it; in ſome manufactories they mix 20, and in others 24 meaſures of clay with four of flint. Theſe proportions, if eſtimated by the weight of the materials, would probably give for the flint-ware about three cwt. of clay to one cwt. of flint, and for the yellow ware ſomewhat more clay. The proportion, however, for both ſorts of ware depends very much upon the nature of the clay, which is very variable even in the ſame pit. Hence a previous trial muſt be made of the quality of the clay, by burning a kiln of the ware. If there is too much flint mixed with the clay, the ware, when expoſed to the air after burning, is apt to crack; and if there is too little, the ware will not receive the proper glaze from the circulation of the ſalt vapour.

This glaze, even when it is moſt perfect, is in appearance leſs beautiful than the glaze on the yellow ware.

The yellow glaze is made by mixing together in water, till it becomes as thick as cream, 112lb. of white lead, 24lb. of ground flint, and 6lb. of ground flint glaſs. Some manufactories leave out the glaſs, and mix only 80lb. of white lead with 20lb. of ground flint: and others doubtleſs obſerve different rules, of which it is very difficult to obtain an account.

The ware before it is glazed is baked in the fire: by this means it acquires the property of ſtrongly imbibing moiſture; it is therefore dipped in the liquid glaze, and ſuddenly taken out; the glaze is imbibed into its pores, and the ware preſently becomes dry. It is then expoſed a ſecond time to the fire, by which means the glaze it has imbibed is melted, and a thin glaſſy coat is formed upon its ſurface: the colour of this coat is more or leſs yellow, according as a greater or leſs proportion of lead has been uſed. The lead is principally inſtrumental in producing the glaze, as well as in giving it the yellow colour; for lead, of all the ſubſtances hitherto known, has the greateſt power of promoting the vitrification of the ſubſtances with which it is mixed. The flint ſerves to give a conſiſtence to the lead during the time of its vitrification, and to hinder it from becoming too fluid, and running down the ſides of the ware, and thereby leaving them unglazed.

The yellowiſh colour which lead gives when vitrified with flints may be wholly changed by very ſmall additions of other mineral ſubſtances. Thus, to give one inſtance, the beautiful black glaze, which is fixed on one ſort of the ware made at Nottingham, is compoſed of 21 parts, by weight, of white lead, of five of powdered flints, and of three of mànganeſe. The Queen's ware at preſent made is much whiter than formerly.

The coarſe ſtone ware made at Briſtol conſiſts of tobacco-pipe clay and ſand, and is glazed by the vapour of ſalt, like Staffordſhire flint-ware; but it is far inferior to it in beauty.

Chaptal tried various methods to glaze pottery, and two among them ſucceeded well enough in his opinion to juſtify his publiſhing them. The firſt conſiſts in mixing the earth of Murviel, which appears to be a fuſible or compound clay, in water, and dipping the pottery therein: this done, they are ſuffered to dry; after which they are plunged into a ſecond water, in which levigated green glaſs is mixed. This covering of vitreous powder fuſes with the clay of Murviel, and the reſult is a very ſmooth, very white, and very cheap glazing.

The ſecond method conſiſts in immerſing the dried pottery into a ſtrong ſolution of ſea ſalt, and afterwards baking them. The trial which Chaptal made in his furnaces gave him reaſon to expect that this method might be uſed in large works.

He likewiſe obtained a very black glazing by expoſing pottery ſtrongly heated to the fumes of ſea-coal. He coated ſeveral veſſels in this manner by throwing a large quantity of coal in powder into a furnace, wherein the pottery was ignited to whiteneſs. The effect, he informs us, is ſtill more complete, when the chimneys or tubes of aſpiration of the furnace are at that moment cloſed, and kept ſo for ſome minutes.

Some potteries can ſuſtain a ſudden application of heat and cold ſufficiently well for the uſes of a kitchen, and are therefore called fire-ware; but theſe are always the coarſeſt, leaſt baked, and the glazing of which is the ſofteſt. They alſo do not laſt long when much uſed; for it is abſurd to ſuppoſe, as ſome perſons do, that pottery may be made capable of ſuſtaining fire like a metal veſſel. We are certain, that the beſt of this kind which are employed for this purpoſe, break as ſoon as they are put upon the fire. They do not indeed break ſo as to ſeparate in pieces, or even to let liquors paſs through them; but many ſmall cracks are formed, which we may be aſſured of by the crackling heard upon their being firſt ſet on the fire, by the many cracks which may be perceived in their glazing, and by their ceaſing to ring when ſtruck, after they have been once heated. Each time that theſe veſſels are ſet on the fire, many ſmall imperceptible cracks are formed in them, which by frequent uſe become ſo numerous, that the veſſel may be broken by the leaſt force. Thus all the difference betwixt the potteries which are intended to be uſed on the fire, and the good ſtone-ware which is not intended for that purpoſe, is, that this latter kind may be broken at once, when heated and cooled careleſsly, whereas the former is broken by degrees. Nevertheleſs the fire-ware is uſeful, as it can ſerve for a ſhort time.

Tobacco-pipes require a very fine, tenacious, and refractory clay, which is either naturally of a perfectly white colour, or, if it have ſomewhat of a gray caſt, will neceſſarily burn white. A clay of this kind muſt abſolutely contain no calcareous or ferruginous earth, and muſt likewiſe be carefully deprived of any ſand it may contain, by waſhing. It ought to poſſeſs, beſides, the capital property of ſhrinking but little in the fire. If it ſhould not prove ſufficiently ductile, it may be meliorated, by the admixture of another ſort. Laſt of all, it is beaten, kneaded, ground, waſhed and ſifted, till it acquires the requiſite degree of fineneſs and ductility.

When after this preparation the clay has obtained a due degree of ductility, it is rolled out in ſmall portions to the uſual length of a pipe, perforated with a wire, and put, together with the wire, into a braſs mould rubbed over with oil, to give it its external form; after which it is fixed in a vice, and the hollow part of the head formed with a ſtopper. The pipes thus brought into form are cleared of the redundant clay that adheres to the ſeams, a rim or border is made round the head, they are then marked with an iron ſtamp upon the heel, and their ſurfaces ſmoothed and poliſhed. When they are well dried, they are put into boxes and baked in a furnace. In the Dutch manufactories, theſe boxes conſiſt of conical pots made of clay, with conical lids, with a tube paſſing through the middle of them, by which the pipes are ſupported; or elſe they are long clay boxes, in which the pipes are laid horizontally, and ſtratified with fragments of pipes pounded ſmall.

Laſtly, the pipes, when baked, are covered with a glazing or varniſh, and afterwards rubbed with a cloth. This glazing conſiſts of a quarter of a pound of ſoap, two ounces of white wax, and one ounce of gum-arabic or tragacanth, which are all boiled together in five pints of water for the ſpace of a few minutes.

All the operations where great heat is employed require veſſels of baked earth; becauſe theſe alone can ſuſtain at once the action of violent fire and of chemical ſolvents. Veſſels made of good baked clay eminently poſſeſs theſe two qualities, and are the beſt which can be employed in chemiſtry; but as they have the inconvenience of breaking by ſudden application of heat and cold, and as many operations do not require veſſels ſo denſe, mixtures of earth have been uſed, of which crucibles are made, capable of being rendered ſuddenly red-hot, and ſuddenly cooled without breaking, and ſufficiently denſe to contain metals and other matters in fuſion during a long time. The beſt crucibles of this kind are brought from Heſſe in Germany. Theſe crucibles are made with a good refractory clay, mixed, according to Pott, with two parts of ſand of a middling fineneſs, from which the fineſt part has been ſifted. The mixture of ſand with clay produces two good effects; the firſt, to make the clay leaner, as it is called, and thus to prevent the clay from cracking by the contraction it ſuſtains during its drying; and ſecondly, to prevent its acquiring too great cloſeneſs and compactneſs of texture by being baked. Thus we obtain crucibles moderately denſe, capable of containing metals and other things in fuſion, and infinitely leſs ſubject to break by heat and cold than thoſe made of pure clay.

The particles of the ſand mixed with clay in this compoſition for crucibles ought to be rather of a moderate ſize than very fine; becauſe, as Pott remarks, the former renders the crucibles much leſs apt to crack than the latter. In the ſecond place, that chemiſt forbids the uſe of ſand, flints, or other earths of that kind, in the compoſition of crucibles intended to contain glaſſes or vitrifying matters a long time in fuſion; becauſe theſe vitreous matters act upon ſand, flints, and all thoſe called vitrifiable earths; by which means theſe crucibles are ſoon penetrated and melted.

This inconvenience is prevented, and all the advantages obtained from a mixture of ſand are procured, by ſubſtituting to the ſand a good baked clay in groſs powder. In this manner are made the pots which contain the vitrifiable materials in glaſs-houſe furnaces, ſome of which reſiſt the continued fires employed there during three weeks or a month. The pots indeed uſed in glaſs-houſes frequently ſuſtain a conſtant fire during ſeveral months, and ſometimes even a year. They become gradually more and more thin, the glaſs or flux contained probably diſſolving them thus ſlowly.

The quantity of burnt clay in the compoſition for crucibles varies in proportion to the nature of the crude clay from 1, 2, 2½, or even three parts of the former, to one of the latter. In general, the ſtronger, more tenacious and compact the crude clay is, the larger quantity of burnt clay ought to be mixed with it.

The crucibles made in France are compoſed on the ſame principles. They are made of clay mixed with broken butter-pots, which are a ſtone-ware made in Normandy and Picardy. Theſe crucibles reſiſt admirably well ſudden heat and cold, and they would be excellent if the crude clay which enters into their compoſition was capable of reſiſting a violent fire: but this clay being mixed with martial and pyritous matters ſwells in the fire, and begins to melt. Beſides, theſe crucibles owe their good quality of not breaking by ſudden application of heat and cold to their little denſity, which is attended with this inconvenience, that they are penetrable by very fluid matters.

We may from what has been ſaid perceive the difficulty, perhaps the impoſſibility, of making perfect crucibles. Pott has made ſo many experiments on this ſubject, that he ſeems to have exhauſted it. The baſis of all his compoſitions was clay; but this he mixed in different proportions with metallic calxes, calcined bones, calcareous ſtones, talks, amianthus, aſbeſtus, pumice-ſtones, tripoli, and many others, from none of which did he obtain a perfect compoſition, as may be ſeen from his Diſſertation: hence it may be concluded, that we muſt have in our laboratories crucibles of different kinds ſuitable to the ſeveral operations:

Paris crucibles, when the matters contained are not too fluid, and the fire is not too ſtrong; Heſſian crucibles, when ſimilar matters are to be expoſed to a violent heat; and crucibles of baked clay, for vitreſcent matters and penetrating fluxes.

Crucibles may poſſibly be made better than any hitherto known, and of more extenſive uſe. The eſſential point is, to obtain a very refractory clay free from pyritous matter and ferruginous earth, from which the ſand muſt be waſhed. This muſt be mixed with two or three parts of the ſame clay baked and pounded groſsly; and of this mixture or paſte crucibles muſt be formed in moulds, and baked in a very ſtrong fire. As retorts and cucurbits are deſigned for the diſtillation of liquors generally very corroſive and penetrating, they ought to be made of ſtone-ware.

To the above obſervations on crucibles, which are extracted from Macquer's Dictionary, I ſhall add ſome farther extracts made by Keir from Pott's Diſſertation above quoted.

1. Crucibles made of fat clays are more apt to crack, when ſuddenly expoſed to heat, than thoſe made of lean or meagre clays. Meagre clays are thoſe in which a conſiderable quantity of ſand is mixed with the pure argillaceous earth, and fat clays are thoſe which contain but a ſmall proportion of ſand. 2. Some crucibles become porous by long expoſure to fire, and imbibe part of the contained metals. This inconvenience is prevented by glazing the internal and external ſurfaces, which may be done by moiſtening theſe with oil of tartar, or by ſtrewing upon them, when wetted with water, powdered glaſs of borax. Theſe glazings are not capable of containing glaſs of lead. 3. Crucibles made of burnt clay groſsly powdered, together with unburnt clay, were much leſs liable to crack by heat than crucibles made of the ſame materials, but in which the burnt clay was finely powdered, or than crucibles made entirely of unburnt clay. 4. If the quantity of unburnt clay be too great, the crucible will be apt to crack in the fire. Crucibles made of ten ounces of unburnt clay, ten ounces of groſsly powdered burnt clay, and three drams of calcined vitriol, are capable of retaining melted metals, but are pervaded by glaſs of lead. The following compoſition is as good or better than the preceding: Seven ounces of unburnt clay, fourteen ounces of groſsly powdered burnt clay, and one dram of calx of vitriol. Theſe crucibles may be rendered more capable of containing glaſs of lead, by lining their internal ſurfaces, before they are baked, with burnt clay diluted with water. They may be further ſtrengthened by making them thicker than is uſually done, or by covering their external ſurfaces with ſome unburnt clay, which is called arming them. 5. The compoſition, of which crucibles the moſt capable of containing glaſs of lead were made, was eighteen parts of groſsly powdered burnt clay, as much unburnt clay, and one part of fuſible ſpar. Theſe crucibles muſt not, however, be expoſed too ſuddenly to a violent heat. 6. Crucibles capable of containing very well glaſs of lead, were made of twenty-four parts of unburnt clay, four parts of burnt clay, and one part of chalk. Theſe required to be armed. 7. Plume-alum powdered, and mixed with whites of eggs and water, being applied to the internal ſurface of a Heſſian crucible, rendered it capable of containing glaſs of lead during a long time. 8. One part of clay and two parts of Spaniſh chalk made good crucibles. The ſubſtance called Spaniſh chalk is not a calcareous earth, but appears to be a ſteatites. 9. Two parts of Spaniſh chalk and one part of powdered tobacco-pipes made a good compoſition for lining common crucibles. 10. Eight parts of Spaniſh chalk, as much

burnt clay, and one part of litharge, made ſolid crucibles. 11. Crucibles made of black lead are fitter than Heſſian crucibles for the melting of metals; but they are ſo porous, that fuſed ſalts paſs entirely through them. They are more tenacious than Heſſian crucibles, are not ſo apt to burſt in pieces, and are more durable. 12. Crucibles placed with their bottoms upwards are leſs apt to be cracked during the baking than when placed differently. 13. The paſte of which crucibles are made ought not to be too moiſt, elſe when dried and baked they will not be ſufficiently compact: hence they ought not to be ſo moiſt as to be capable of being worked on a potter's lathe, but they muſt be formed in braſs or wooden moulds. See Pott's Diſſertation on Chemical Veſſels.

Scheffer ſays, that the beſt crucibles cannot eaſily contain metals diſſolved by ſulphur, in the operation of parting by means of ſulphur. See PARTING. He ſays, that they may be made much more durable and ſolid, by ſteeping them a few days in linſeed oil, and ſtrewing powdered borax upon them before they are dried. Mem. Sued. xiv. 1752.

POWDER. This word ſignifies preciſely the ſame thing in chemiſtry as it does in common life. Any ſolid matter divided into ſmall particles not adherent to each other forms a powder. When any ſubſtance is pulveriſed, the number of ſurfaces or quantity of ſurface in the whole will obviouſly be greater the finer the powder. Various contrivances are in daily uſe to pulveriſe different bodies. The peſtle and mortar is uſed in the operation of pounding. The circulation of two mill-ſtones againſt each other, with grooves cut in the face of each to admit the ſubject of action, is uſed in the operation of grinding. By an hard ſmooth ſtone rubbed on the face of another, alſo ſmooth, trituration is effected; for which purpoſe water or ſome other fluid is added to the ſubſtance to be triturated. And laſtly, waſhing is uſed to ſeparate the ſmaller particles of powder from the larger or heavier; whether the latter be chiefly wanted, as in mine-works, or the former, as in waſhing emery and other fretting powders.

Several chemical and a ſtill greater number of medical preparations are known by the name of powders.

POWDER OF ALGAROTH. This preparation is alſo called emetic powder, or mercurius vitæ. It is produced by adding water to the butter of antimony; and is a white calx of the ſemi-metal. In doſes from three to four grains it is violently emetic and purgative; but inconſtant in its effects, as are all the preparations of antimony which are not in the ſaline ſtate. Modern medical practice has rejected it.

POWDER, GUN. See GUN-POWDER. This powder is well made when it explodes with a bright clear flame, and does not ſoil the plane on which it is burned. It is alſo reckoned a good criterion, when a number of ſmall ſeparate heaps of powder are laid at a ſmall diſtance from each other, and one being fired does not ſet fire to the reſt; becauſe this can only be done by ſmall grains of powder or coal being thrown at a diſtance before they are completely burned. Such powder muſt therefore be ſlow and weak in its action. But the real force is beſt aſcertained from the mechanical effect. This is meaſured by filling a ſmall inſtrument or piſtol called the powder proof, and firing it. The exploſion drives the index of a wheel through a greater or leſs number of diviſions, as the powder is ſtronger or weaker. Other inſtruments more eaſily compared with each other have been made, in which the exploſion from a gun drives upwards a plug or piſton loaded with an heavy weight, to heights which vary with the force. But the deſcription of theſe is in ſome meaſure foreign to the general objects of chemical ſcience.

The analyſis of the chemiſt cannot ſhew whether the parts of gunpowder be intimately mixed as they ought to be to give it all its force, nor whether the ſaline matter has been partly ſeparated, or the coal rendered leſs inflammable by damp in the keeping. But it is nevertheleſs on many accounts deſirable and neceſſary to know the component parts of particular parcels of this ſubſtance. For this purpoſe the nitre may be extracted by boiling in water, and its quantity aſcertained by evaporation and cryſtallization, or otherwiſe by drying and weighing the reſidue, which is the charcoal and ſulphur. From this reſidue the ſulphur may be burned off on a metallic plate by a gentle heat ſufficient only to make it ſmoke by day-light. The remainder will be the charcoal.

Robins, in his Principles of Gunnery, has ſhewn that the force of the hot elaſtic fluid extricated by the exploſion of gunpowder is nearly equal to a thouſand times the preſſure of the atmoſphere. This force is ſeldom applied to any of the arts of peace, on account of the expence.

POWDER FULMINATING. See Fulmination.

PRASE. A blueiſh chryſolite. See Precious Stones, No. V.

PRECIOUS STONES. Under this article I ſhall collect the general properties and facts relating to the precious ſtones, in addition to the ſhorter notices to be found under their reſpective titles *.

Stones which are highly prized for their external appearance, and on that account denominated precious, are, 1. Diamond. 2. Ruby. 3. Sapphire. 4. Topaz. 5. Chryſolite. 6. Beryl. 7. Emerald. 8. Hyacinth. 9. Amethyſt. 10. Garnet. 11. Tourmalin. 12. Opal. And of inferior note are, 13. Rock Cryſtal. 14. Cats Eye. 15. Hydrophanes or Oculus Mundi. 16. Chalcedony. 17. Moon Stone. 18. Onyx. 19. Carnelion. 20. Sardonyx. 21. Agates; and 22. The Labradore Stone.

I. The Diamond. The chief mines of diamonds are in the Aſiatic Peninſula on this ſide of the Ganges, towards the Gatte mountains, not only at Golconda, but in many other parts, as Coulour, Raolconda, Biſnagar, Nouſtafanagar, Parteal, Latawar, Soumalpour and Malacca; ſome of which are now exhauſted: beſides theſe, diamonds are found in the iſland of Borneo; and above all in Braſil, in the province of Serra do Frio, in the place called Cay de Marin, near the river Milho-Verde. See Bomare's Mineralogy, vol. i. and Romé de l' Iſle's Criſtallographie, vol. ii. As to the ſoil or mine in which diamonds are found, M. Bomare ſays, that they are ſometimes found ſtuck to rocks, and in cluſters like rock-cryſtals; but this ſeems to be very ſeldom the caſe. Tavernier ſays (page 327 of his ſecond volume), that they are found in a ſandy earth, and in the looſe earth that fills the clefts of ſome rocks. That their mines at Gani, otherwiſe called Coulour, where ſix thouſand people were at work, are in a marſhy ground. At Soumalpour the diamonds are found in the bed of the river Gouel, whoſe waters are turned with great labour into another channel for this purpoſe: and Engeſtrom ſays he was informed by very good authority, that the Braſilian mines of diamonds are worked in the ſame manner. At Borneo it is alſo in the river Succadan that diamonds are found, according to the ſame Tavernier.

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* I have chiefly availed myſelf of the ſecond edition of Cronſtedt's Mineralogy, and the authors quoted by Magellan in his valuable Notes.

nier. But what this famous traveller ſays of certain diamonds which have a greeniſh cruſt, is very remarkable. Theſe green diamonds burſt into pieces, either whilſt they are in working to receive a proper figure, or when in the act of being poliſhed on the wheel: and he mentions a large diamond, bought by a Jew named Edward, for which 25 thouſand piaſtres (about 500 pounds ſterling) had been offered when brought to Leghorn, that on being ſent to Venice, in order to be cut there, burſt into nine pieces whilſt poliſhing on the wheel. This conveys, it ſeems, the idea of ſome ſimilarity between diamonds and the lachryma Batavica, which may perhaps be extended to all hard cryſtallizations like thoſe of gems. See GLASS.

The ſpecific gravity of diamonds, according to Wallerius, is from 3,100 to 3,400: Haukſbee judges it to be 3,666: Ellicot, 3,519: Briſſon, 3,5212.

Diamonds commonly cryſtallize into octoedral forms, which however are often found ſomewhat irregular, eſpecially when the ſurface inclines to cryſtallize, during the ſhooting of the whole cryſtal, and alſo when ſeveral of them unite together into a group; in which latter circumſtance the one hinders the other from aſſuming its regular form. But the octoedral is not the only regular form which the diamond aſſumes. Engeſtrom mentions a rough diamond in its native ſtate, in a regular cube, with its angles truncated or cut off.

Diamonds of a dodecaedral form are not uncommon: thoſe of Malacca are rhomboidal and cubic: and ſome have been found of fourteen ſides or planes.

The ſubſtance of diamonds is lamellated, conſiſting of very thin plates like thoſe of talc, but extremely hard and intimately united, the direction of which the lapidary muſt diſcover, not only to cleave the ill-ſhaped diamonds, but to cut and ſhape them properly. This laſt operation is performed by rubbing a diamond with another till it has the required figure. It is afterwards poliſhed upon an horizontal wheel of ſteel, employing the ſame powder that falls from their rubbings, with common olive oil. Such diamonds as have an irregular grain like the knots of wood cannot well be ſhaped: and lapidaries call them diamonds of nature. See Bomare's Mineralogy, p. 393, vol. i. The art of cutting diamonds was invented in 1476, by Louis de Berquen, a native of Bruges in the Auſtrian Netherlands.

Jeffries, in his Treatiſe on Diamonds, aſſerts very poſitively, that, upon the ſtricteſt examination, there is not leaſt difference between the beſt oriental and Braſilian diamonds. It is nevertheleſs aſſerted that ſome of the latter are not combuſtible.

There are diamonds of all colours, though not deeply ſo, viz. ſome incline to the roſe colour, others to green, blue, brown, black: and ſome have black ſpecks. Tavernier ſaw one of this laſt kind weighing about 56 carats in the treaſury of the Mogul; he ſays alſo, that the mines of Carnatica produce yellow and black diamonds: and Mr. Dutens ſays (page 13 of his Treatiſe) that he ſaw a black diamond at Vienna, in the collection of the Prince de Lichtenſtein.

The diamond becomes phoſphoric, either by being expoſed to the ſolar rays, or by being made red hot in a crucible on the fire. When rubbed it becomes electric, and attracts ſmall pieces of ſtraw, paper, feathers, hairs of animals, ſilk, &c. M. D'Arcet found, not only that diamonds included in porcelain crucibles cloſe, or covered with perforated lids, and expoſed to the long and intenſe heat of a porcelain furnace, were perfectly diſſipated; but alſo, that this ſtone could in a few hours be totally volatilized with a much inferior degree of heat, by expoſing it in a coppel under the muffle of an eſſay-furnace. In this latter experiment, he obſerved, that the diſſipation was gradual, and that it was effected by a kind of exfoliation. The diſſipation of diamonds expoſed in coppels was confirmed by Macquer, who further obſerved, that the diamonds were, before the diſſipation began, rendered by the fire brilliant and ſhining, as it were with a phoſphoric light. In order to determine whether the diſſipation of diamonds was actually effected by their reduction into vapour, or by a combuſtion or other effect of air upon them, Meſſrs. Lavoiſier, Macquer and Cadet expoſed diamonds to intenſe heat in an earthen retort during ſeveral hours, but without any other effect than that their poliſh was deſtroyed, and about $\frac{1}{7}$ of their weight diminiſhed. M. Mitouard put diamonds in a tobacco-pipe filled with pounded charcoal and accurately cloſed with lute. He further ſecured the diamonds from acceſs of air or flame, by placing the tobacco-pipe in a crucible to which another crucible was inverted and carefully luted. The diamonds thus ſecluded from external air having been expoſed to the moſt intenſe heat which could be excited in a well conſtructed furnace, were not thereby altered or diminiſhed. M. Mitouard was induced to believe, that the charcoal conduced to the preſervation of diamonds not merely by excluding the air, but by ſome peculiar property, which he ſuppoſes may be the ſame as that by which this ſubſtance defends metals from deſtruction by fire. He was confirmed in his opinion by obſerving that diamonds, were not preſerved from the action of fire by ſurrounding them with powder of chalk, and of calcined hartſhorn, and including them in cloſe veſſels, ſo well as when the charcoal had been employed. Some chemiſts even thought that the perfect excluſion of air alone was ſufficient to preſerve diamonds, and doubted whether the balls and crucibles of porcelain employed by M. D'Arcet had excluded the air with ſufficient accuracy. Indeed, in one of M. D'Arcet's own experiments, a diamond included in a ball of porcelain had reſiſted the action of fire. In order to aſcertain this queſtion, M. Cadet expoſed diamonds in covered and luted crucibles to the violent heat of a forge during two hours; by which operation the diamonds loſt only $\frac{1}{16}$ part of their weight. He infers that the deſtruction of diamonds by fire in open veſſels is not a true volatilization, but merely an exfoliation, cauſed by the fire expanding the air contained between the thin plates of which theſe ſtones conſiſt, and that by this exfoliation or decrepitation theſe plates are reduced to ſo fine a powder as to eſcape obſervation. M. D'Arcet objected againſt the experiments of his adverſaries, that they were not of ſufficient duration to decide againſt his, which had laſted ſeveral days. He renewed and multiplied his experiments, which confirmed him in his opinion of the volatilization of diamonds in veſſels perfectly cloſed; and that this effect of fire on diamonds is not a mere exfoliation or mechanical ſeparation of the plates of which theſe ſtones conſiſt, he infers from the parts of the diamonds pervading the moſt ſolid porcelain crucibles without being perceptible, and from the luminous appearance firſt noticed by M. Macquer, and which was afterwards obſerved by M. Roux to be an actual flame. Some beautiful experiments have been lately made at Prague on the combuſtion of diamonds. (Annales de Chimie, for November 1791.) To the diamond which is to be burned is faſtened a piece of iron wire, which is then made red hot, and plunged into a jar containing dephlogiſticated air. The fire from the iron wire ſpreads to the diamond, which burns with the greateſt vividneſs. Some diamonds, ſuch for inſtance as thoſe which come from Braſil, cannot be made to burn by this treatment. On account of the dearneſs of theſe ſubſtances, the experiments have not yet been carried to any great length; but Mr. Landriani hopes to prevail upon the Emperor to have them repeated, with a view to aſcertain the quantity and quality of the reſidues, the alteration which the air in which they are burned undergoes, and the cauſe of the great difference in the qualities of diamonds. For the value of diamonds, ſee DIAMONDS.

The jargon has been conſidered as a ſoft diamond, but is very different in its nature. See JARGON.

II. The RUBY. Red ruby. Adamas ruber. Rubinus. The ruby was formerly conſidered as of the ſame kind with the diamond; but latter experiments ſhew how widely diamonds differ from any other gems by their conſtituent parts.

According to Tavernier, vol. ii. p. 356, and Dutens, p. 23, all coloured hard ſtones are called rubies in the Eaſt Indian mines, adding to each its different colour for diſtinction ſake; but there are alſo ſome ſoft ſtones of this kind which they call bacan: and Wallerius, as well as Romé de l'Iſle, rightly aſſerts that the oriental (the hard and brilliant) rubies, ſapphires and topazes are the very ſame ſtone, the colour excepted. It is certain that they have the ſame form, and ſome are partly red, and partly blue, yellow, or quite colourleſs. As to their colour, it proceeds from the martial mixture which enters into their compoſition. Rubies are found in the Capelan mountain of Pegu, at Caos Ava, Biſnagar, Calicut, Cananor, Ceilan and Braſil. They are found in the ſands of rivers of a red colour, in an argillaceous earth of a hard texture, and of a greeniſh colour; and ſometimes they are adherent to red rocks.

Tavernier ſpeaks of 108 rubies in the Mogul's throne, from 100 to 200 carats, and of a round one of almoſt two ounces and a half: and Robert de Berquen ſpeaks of one of 244, another of 123, and another of 209 carats.

Of rubies, according to Cronſtedt, there are four kinds. 1. The ruby of a deep red colour, inclining a little to purple. This is the carbunculus of Pliny; but all red gems were ſo called by the ancients. Thoſe of a deeper colour are called almandini, according to Wallerius; and the jewellers call this the oriental ruby on account of its hardneſs and brilliancy. By the experiments of M. D'Arcet the ruby does not loſe its colour in the greateſt fire: but Henckel, by means of a burning glaſs, ſoftened it ſo as to receive the impreſſion of a ſeal of jaſper. This ruby is the hardeſt gem after the diamond; and being rubbed becomes electric.

Its ſpecific gravity, according to Bergman, is from 3,180 to 4,240. According to Briſſon, it is = 4,283.

Its texture is foliated like that of the diamond: it is fuſible with borax in a violent and long continued heat; and forms a tranſparent glaſs of a pale green: it does the ſame with microcoſmic ſalt: but with ſedative ſalt, or mineral or vegetable alkali, the glaſs is opake and of various colours. See the various experiments of Meſſrs. Bergman and Achard on this kind of gems.

A perfect ruby above 3½ carats weight, according to Dutens, is more valuable than a diamond equally heavy: if it weighs one carat, it is worth 10 guineas; if two carats 40 guineas; if three carats, 150 guineas; if ſix carats, above 1000 guineas.

2. The ſpinell ruby of a ponceau red, that is, of a bright corn-poppy-flower colour.

Romé de l'Iſle from Briſſon acquaints us, that the form of this ruby is octoedral: its ſpecific gravity is 3,760, of that from Braſil 3,531.

Theſe rubies are found in Hungary, Sileſia, Bohemia, and ſome in Braſil according to Bomare and R. de l'Iſle. Their value, according to Dutens, is reckoned at the half of diamonds of the ſame weight.

Rubies are artificially made from topazes of Braſil, of a ſmoky appearance, by giving them a gradual heat in a crucible filled with aſhes, until it is red-hot. See R. de l'Iſle and Dutens, who quote the Hiſtory of the Royal Academy of Sciences of Paris for the year 1747. It was Dumelle, a jeweller, who communicated this ſecret to Mr. Guetard of the Royal Academy of Sciences at Paris.

3. The balaſs-ruby, pale red inclining to violet. This is ſuppoſed to be the mother of rubies: it comes chiefly from Braſil, although ſome come likewiſe from the Eaſt Indies. The value of the balaſs-ruby is at the rate of thirty ſhillings per carat. Dut.

4. The rubicell, of a reddiſh colour. But authors do not agree in the characters of theſe ſtones.

They come alſo from Braſil, but it is ſaid that their colour is loſt in the fire: if ſo, they muſt be of a different nature from the Braſilian topaz, which gets a red colour from fire, as has been already obſerved.

The rubino di rocca of the Italians, or rubinus rupium, according to Bomare, is a true garnet, of a deep red and violet, or of the amethyſt colour. What is called ruby of arſenic, or of ſulphur, is the realgar: the ruby of zinc is the red blend: and the ruby of ſilver is the red ſilver ore, &c.

III. The SAPPHIRE. Sapphirus gemma. It is tranſparent, of a blue colour, and is ſaid to be the hardeſt next to the ruby, or diamond.

The ſapphires in their rough and native ſtate cryſtallize moſt generally in two oblong hexagonal pyramids pointed at their tops, and joined at their baſis: yet they are ſometimes found of an hexagonal columnar form. In the fire they loſe their blue colour.

Engeſtrom informs us, that he has found ſome of the deep blue ſapphires, and ſome of a milky colour, which, when looked through, varied their colours in the ſame manner as the milky blueiſh opals. This is however no reaſon why thoſe opals ſhould be marked under the name of ſapphire, and leſs ſo ſince there are alſo agates found of the ſame quality. This might rather give riſe to a queſtion, whether the name of milky or blueiſh opal is not to be conſidered as a vague term, ſince that principal quality is found in ſtones of a ſomewhat different nature, though they all belong to the flinty order.

Sapphires are ſaid to be found in Alſatia, at St. Amarin; but accounts of this kind are in general not to be depended upon, as the fluors are frequently met with in collections and in the druggiſts' ſhops under the name of ſapphires, when they are of a deep blue colour; not to mention that the quartz is always termed a precious ſtone, whenever it is found clear and of a fine colour. The ſapphire is ſaid to loſe its blue colour in the fire. Thoſe which are but little tinged, are called white ſapphires. The ſapphire is ſeldom found of a very deep blue colour, and free from parallel flaws which run through it.

The fine hard ſapphires, or, as jewellers call them, the oriental ones, are according to Engeſtrom of the ſame kind as the ruby and the topaz, their colour excepted.

The late King of France, as we are informed by R. de l'Iſle and R. de Berquin, had one with a yellow ſtripe of a fine topaz in the middle. Some are found half green and half red. This ſubſtance is foliated like the ruby; thoſe from Puy in Auvergne ſeem to approach to the true ſapphire, by their form and ſpecific gravity; but they loſe both their colour and tranſparency by fire, and become black and even vitrify, according to R. de l'Iſle, which proves that they are of a different kind.

It is ſaid that ſapphires loſe their colour by fire, and remain ſo hard and tranſparent as to paſs ſometimes for diamonds. But Mr. Achard found that they are not altered in the leaſt by fire, in colour, hardneſs, or weight: however, theſe circumſtances may not be common to all ſapphires.

According to Bergman, the ſapphire is the third in hardneſs, the ruby being the hardeſt of all after the diamond: and according to R. de l'Iſle it becomes electric by being rubbed. Its name was taken from Σαπφειρ, the place where they were found, according to Lemery, quoted by Bomare. But it is evident, ſays Engeſtrom, from Pliny (lib. 37. cap. 9.), that the ſapphire of the ancients was our lapis lazuli.

Its ſpecific gravity, according to Bergman, is from 3650 to 3940; but according to R. de l'Iſle the oriental is = 3,994: the Braſilian = 3,1307: and that from Puy = 4,0769. The ſapphire when powdered is fuſible with borax, or with microcoſmic ſalt, into a tranſparent glaſs, as well as with magneſia alba. Bergman and Achard found nearly the ſame reſults from the analyſis of this gem.

They are found in the ſame place as rubies: and thoſe called occidental, are alſo formed in Siberia, Bohemia, Alſace, and Auvergne. Romé de l'Iſle ſpeaks of one of this laſt place, which was entirely green or blue, according to the ſide it was looked through.

Dutens informs us, that a good ſapphire of 10 carats is valued at 50 guineas. If it weighs 20 carats, its value is 200 guineas; but under two carats it may be valued by multiplying the carat at 10s. 6d. into the ſquare of its weight.

Sapphires are preferable to common rubies, for jewelling the pallets of eſcapements, and the holes of wheel-pivots, in aſtronomical watches and clocks, on account of the homogeneous hardneſs of their ſubſtance: becauſe there are red ſtones which are called rubies, but are not uniformly hard.

IV. The TOPAZ. Topazius gemma. According to Pliny (lib. 37. cap. 8.), this gem took its name from an iſland in the Red Sea, where it was firſt found; but it is evident from his words that it was ſome kind of lapis ollaris, fuſible ſpat, or other kind of ſtone of a greeniſh-yellow caſt, that the ancients called topaz; ſince he ſpeaks of a topaz of a greeniſh colour, and four cubits large, viz. above ſix Engliſh feet (= 68,476 French inches = 72,978 Engliſh inches), which cannot be applied either to our topaz or to our chryſolite, as ſome pretend. It appears, however, from the following chapter of the ſame author, that our topaz was called chryſolite by the ancients, as its name indicates: but what he ſays of one Bocchus, who had ſeen one of thoſe gems of 12 Roman pounds weight, or 10,78 pounds troy, is not incredible; ſince there is now a rough topaz in the Prince's cabinet at the Hague, of the ſhape of an egg, that is upwards of ſeven inches in length, and muſt conſequently weigh conſiderably more than the above. This topaz, which I ſaw many years ago, has the appearance of a pebble rounded by water. Its ſurface and colour reſembled roſin. A conſiderable piece had been broken from one end, where the fracture appears vitreous and the ſtone clear. I ſuppoſe it muſt have been from trials with this piece, that its claim to the character of a topaz was aſcertained.

The topaz, when rough and perfect, is ſold in a cryſtallized form. At Schneckenſtein in Saxony, theſe cryſtals are found of a priſmatical octoedral form, with no points, but flat, and with ſome facets at the top; perhaps the oriental topazes have another figure.

Engeſtrom mentions ſome rough Brazil topazes, which were in his poſſeſſion, and were priſmatical, and of a rhomboidal quadrangular figure, pointed at one end. It is very likely, that theſe, as well as many other cryſtals, may be pointed at both ends, when nothing has interrupted their cryſtallization.

He mentions, beſides theſe, ſome fragments of other topazes in his poſſeſſion, which were likewiſe ſaid to be from the Brazils, all which were priſmatical, but plainly ſhewed that ſome are pentagonal, and others regular hexagons with points.

The topazes loſe their colour in the fire; but ſome of them turn red in a certain degree of heat, and are therefore very much uſed inſtead of the pale rubies, and even are often ſold as ſuch.

According to R. de l'Iſle and Dutens, the topaz is of a lamellated ſtructure, like the other gems: it is the third in hardneſs after the diamond, and on being rubbed becomes electric. Its form is priſmatic of ſix or eight ſides, ending in two quadrangular pyramids. Some are ſtriated, ſome are of a rhomboidal figure, and ſome are even of a cubic form.

Their ſpecific gravity is from 3,460 to 4,560, according to Bergman; but according to Briſſon it is equal to 4,0106: and R. de l'Iſle informs us that thoſe of Brazil = 3,5365.

The topaz appears white when reduced to powder, melts eaſily with borax and lime; and when calcined is conſiderably altered, loſes its colour, and acquires weight.

The beſt topazes are called oriental: they have the ſame properties as rubies and ſapphires, the colour excepted. They are found in Pegu, Ceylon, Arabia, Egypt, and Brazil.

Thoſe called occidental loſe their colour, tranſparency, and hardneſs in the fire. The topazes from Saxony, though they are as hard as the oriental, agree with the occidental in their other properties.

Experiments by fire have been made on the Schneckenſtein topazes by Mr. Pott, as may be ſeen in his Lithogeognesia. The rock of Schneckenſtein in the valley of Danneberg in Voigtland of the Upper Saxony, is about 80 feet high, and about three times as much in its baſe: it is as hard as the topazes themſelves, and its powder is employed in poliſhing them.

But we have ſome topazes from Brazil, whoſe ſubſtance is widely different, as they do not loſe their tranſparency nor hardneſs by fire; but even turn red like a fine ruby, and are ſold as ſuch. Thoſe from Bohemia are in large priſms: their colour inclines to the hyacinth: and ſome are colourleſs, as is the caſe with ſome ſapphires.

Tavernier ſpeaks of a very fine topaz belonging to the Mogul, of $157\frac{1}{3}$ carats: and many others are known of a very large ſize.

The oriental topaz is valued by multiplying the ſquare of its weight in carats into 15 or 16 ſhillings; and the occidental one at the rate of five or ſix ſhillings.

To the Schneckenſtein topaz Cronſtedt refers, 1. The pale yellow topaz, which is almoſt colourleſs, and is found at Schneckenſtein. 2. The yellow topaz from Schneckenſtein. 3. The deep yellow, or gold-coloured topaz, which is the oriental topaz; and 4. The orange-coloured topaz.

V. The CHRYSOLITE. See the article.

VI. The BERYL. This is a blueiſh-green topaz, which varies in its colours, and is called, when of a ſea-green colour, the aqua marina, but when more green the beryl.

According to R. de l'Iſle the aqua marina found by Pallas in the mountain Adontſcholo of Siberia, the Peru emerald, and the chryſolite from Brazil, are nearly the ſame, both in their form and in their ſpecific gravity. Briſſon ſays, that this laſt of the Siberian aqua marina is 2,7213. According to Sage, quoted by R. de l'Iſle, it does not vitrify in the fire, but becomes opake, and cracks in its ſurface.

The great Saxon mineralogiſt, and ſuperintendant of the mines, M. Pabſt von Oheim, who has a very inſtructive collection, likewiſe poſſeſſes ſuch an octoedral aqua marina, on a piece of quartz druſe from Schneckenſtein, growing among ſome yellow topazes. It has no points, and the whole cryſtal has a flaw acroſs the priſm.

Mr. Dutens informs us, that the beryl and aqua marina are tranſparent, and of a green blue colour: ſome jewellers erroneouſly call them by the name of oriental coralina. They come from Ceylan, from the ſhores of Euphrates, from the neighbourhood of mount Taurus, and from Brazil.

Beryls are found in the ſtream-works in Saxony and Bohemia, in the form of pebbles, or round pieces.

VII. The EMERALD. Lat. Smaragdus gemma. Swed. and Germ. Smaragd. Fr. Emerhaude.

The Romans called it the Neronian or Domitian gem. The Perſians and Indians call it pachac: and the Arabians zamarrut, from whence it is ſuppoſed the word ſmaragdus is derived.

According to R. de l'Iſle, the oriental emerald is a true ſapphire of a green colour.

The chief colour of the emerald is green, and it is tranſparent. In their rough or native ſtate, emeralds conſiſt of hexagonal columns, moſtly truncated at both ends. Engeſtrom informs us, that he had ſamples of both tranſparent graſs-green and light green colours, which in a gentle heat became colourleſs; but white and opake in a ſtrong fire, without the leaſt mark of any fuſion.

The ſame author obſerves, that when cryſtallized cockle or ſhirl is found of a green colour, tranſparent, and free from cracks or flaws, it is commonly called emerald by the jewellers, though it is generally of a deeper colour than the true emeralds, and alſo wants their luſtre; and hence it is, that the cockle-ſpar from Egypt is called the mother of emeralds. However it may be, this cockle was in ancient times faſhionable in Egypt, under the name of emerald, though at preſent it is not ſo much valued as the emerald of this (ſiliceous) kind.

Cronſtedt is of opinion that the emerald is, or has been, a cryſtal of its own ſeparate principle, ſince in its qualities it differs both from the above-mentioned and from the rock cryſtal. This however he ſays he cannot poſitively aſſert, as he knows no more of it, than that it is the ſofteſt of precious ſtones, and that when heated it is phoſphoreſcent like the fluors.

According to Wallerius, the emerald, when heated to a white heat, becomes of a deep blue, and phoſphoreſcent. It however recovers its green colour when cold. When pulverized it becomes white; and melts with borax to a very thin colourleſs glaſs.

Romé de l'Iſle ſays, that it becomes electric by being rubbed.

Its ſpecific gravity, according to Wallerius, is 2,700, or 2,800. Briſſon makes it 2,7755: and Bergman from 2,780 to 3,711.

Of emeralds there are two kinds. 1. The pale green emerald, which comes from the eaſt and from Peru. According to Brunnich, the figure of theſe emeralds is an hexagonal truncated priſm. Their baſis is a vein of white quartz.

The fineſt druſe or cluſter of this kind is to be ſeen at Loretto in the treaſure of the Holy Chapel near Ancona, conſiſting of more than 100 great and ſmall emeralds. A fellow to it is made by art, and both are preſents of the King of the two Sicilies, to repreſent two Mount Calvaries.

2. The dark green emerald. Theſe are columnar, and ſtriped longitudinally; their colour is very dark, and they are hardly tranſparent. The points are generally broken off, though Davilla mentions one in form of a blunted triangular pyramid. There is one with a five-ſided pyramid in the Imperial cabinet at Vienna. Some of them, which muſt be ſelected by trials, have the properties of the tourmalin, of attracting aſhes, when they are laid on burning coals, and acquire a certain degree of heat; but Brunnich ſays, he never could diſcover that they repelled them again.

They do not attract ſo ſtrongly as the tourmalin. The Prince of Noja, in his letter on the tourmalin, mentions the Brazilian emeralds among thoſe hard ſtones, which, when they are put into the fire, receive no electric power like the tourmalin: but he was poſſeſſed of, and tried, ſuch as really had not that quality. The celebrated inſpector of the Auſtrian mines, M. Jacquin, was a witneſs to the experiments of Brunnich.

That which in ſome cabinets is exhibited as the matrix of the emerald, and ſaid to come from Egypt, is nothing but a deep green cockle ſpar, of which colour we likewiſe find cockle, or ſhirl, in the iſland of Uto near Stockholm, and at Norberg, in the province of Weſtmanland.

Mr. Mailet informs us, that in former times the beſt emeralds were found in Egypt.

Pliny mentions (lib. 37. c. 5.) twelve kinds of emeralds: but from his words it clearly appears that many of theſe were different green ſtones, ſo called by the ancients. Theophraſtus ſays (page 65 of Hill's edition), that in the records of the Egyptian kings, mention is made of an emerald four cubits long, and three broad: and of an obeliſk compoſed of four emeralds, which was 40 cubits long, and from four to two cubits wide. Each Egyptian cubit, according to Paucton, is equal to $10\frac{272}{10000}$ French inches, or near 11 Engliſh inches. If theſe and like accounts of large emeralds are to be depended upon, we muſt think they were ſome ſparry fluors like thoſe we have in Derbyſhire, or ſome green glaſſes, like thoſe manufactured in England, which are as beautiful as the true emeralds: and of this kind ſeems to be that large one kept in the Abbey of Reychenau near the Lake of Conſtance, mentioned by Romé de l'Iſle, page 246, vol. ii. of his Cryſtallography, which meaſures above two feet and a half in length.

VIII. The HYACINTH. To the precious ſtones belong alſo the jacinths, or hyacinths, which are cryſtals harder than quartz cryſtals, tranſparent, and of a fine reddiſh-yellow colour when in their full luſtre.

The beſt hyacinths come from Arabia, Calecut and Cambaya. According to R. de l'Iſle and Dutens, they only differ in colour from rubies. They are called oriental, when very hard and brilliant; and they are then reckoned among topazes: but when they are ſoft, they belong to the garnet kind: thoſe from Compoſtella in Spain are of this laſt ſort.

According to Dutens, the ſpecific gravity of this gem is 2,631: but Romé de l'Iſle ſays that Briſſon found it be 3,6873; and thoſe of Europe 3,760.

Hyacinths are formed in priſms pointed at both ends; theſe points are always regular, with reſpect to the number of the facets, being four on each point, but the facets ſeldom tarry: the ſides alſo which form the main body, or column, are very uncertain, both as to their number and ſhape; for they are found of four, five, ſix, ſeven, and ſometimes of eight ſides: and beſides this, the column or priſm is in ſome ſo compreſſed, as almoſt to reſemble the face of a ſpherical facetted garnet.

According to R. de l'Iſle, they are of a dodecaedral form, like the garnet, but their angles are more obtuſe.

R. de l'Iſle and Dutens inform us, that the jacinta la bella of the Italians is a garnet of this yellowiſh hue: but when it is more of a reddiſh colour, it is then called vermeille by the French.

According to Mr. Dutens too, the chryſolectre is a yellow-brown hyacinth, like honey, or amber, but very diſtinct from the above two by being leſs hard, and by not having any electric power.

Theſe cryſtals loſe their colour, become white, and do not melt in the fire; by which qualities chiefly they may be diſtinguiſhed from garnets, which are likewiſe ſometimes found of a colour not inferior to the true jacinths. The reddiſh-yellow garnets from Greenland are ſold by the jewellers for jacinths; ſo are likewiſe the Eaſt Indian garnets of the ſame colour; and, what is ſtill more, there are ſome jewellers that do not know the true diſtinctions between a jacinth and a garnet at all, but buy and ſell the garnets for jacinths, when they are of a fine reddiſh-yellow colour: this muſt in particular be owing to the ſcarcity of the true jacinth.

Cronſtedt had ſome jacinths in his poſſeſſion of a quadrangular figure, which did not melt in the fire, but only became colourleſs. This confirms what has been already mentioned about the jacinths above deſcribed.

IX. The AMETHYST. The amethyſts called occidental are of the ſame nature as rock cryſtals, and have the ſame gradations, viz. of a violet inclining to the purple or roſy colour, or inclining to the blue. They are very often ſemi-tranſparent without any colour in one end, and violet towards the other. The beſt are found in the Vic mountains of Catalonia in Spain, and at Wieſenthal in Saxony, as well as in Bohemia, in Germany, in Italy, and in the province of Auvergne in France.

Cryſtals within the geodes, or hollow agate, are, according to R. de l'Iſle, very often found of an amethyſt colour, and ſome are very fine.

What is now called amethyſt root, or mother of amethyſt, is but a ſparry fluor, of which there are plenty in Derbyſhire. Many fine ornamental pieces are made of this ſubſtance in different forms and ſhapes. Theſe ſpars are found in inſulated maſſes, ſometimes pretty large, but never in the form of large rocks.

X. The GARNET. Lat. Granatus. Swed. Aecta or Klar Granat. French, Granat. Germ. Echter or Klarer Granat. See GARNET.

The garnets of Bohemia, according to Cotes, have a ſpecific gravity of 4,360; and thoſe of Sweden, according to the ſame author, 3,978.

Their colour proceeds from the iron which enters into their compoſition; and M. de Sauſſure aſſerts, that even the fineſt oriental garnets attract the magnetic needle at a ſmall diſtance.

The Syrian garnet is the fineſt and moſt eſteemed. It is of a fine red inclining to the purple colour, very diaphanous, but leſs brilliant than the oriental amethyſt. It ſeems to be the amethyſtizontas of Pliny: the Italians call it rubino di rocca, and it is found in Syria, Calicutt, Cananor, Camboya, and Ethiopia.

The fine garnet of a red inclining to a yellow colour is the foranus of the ancients, the vermeille of the French; and the giacinto guarnacino of the Italians.

Its name is taken from Sorian, or Surian, a capital town of Pegu, from whence theſe gems are brought: when they have a browniſh tint, they are then called hyacinths.

The occidental garnet is of a deep and dark red, and its hardneſs is leſs. However, ſome very fine hard garnets are found in Bohemia. Garnets are found alſo in Hungary, at Pyrna in Sileſia, at S. Sapho in the canton of Berne, in Spain, and in Norway.

The garnet melts in the focus of a good burning glaſs into a brown maſs, which is attracted by the loadſtone, and this ſhews that iron enters conſiderably into its compoſition.

Some garnets are found which contain a little gold. Thoſe called zingraupen by the Germans contain tin.

Magellan thinks it probable, that the lapis alabandicus of Pliny (lib. 36. c. 8.) which was black, and that other which he mentions of a deep purple (lib. 37. c. 7.) among the gems, were both true garnets.

XI. The TOURMALIN. Aſhdrawer. Tourmalinus, lapis electricus. Trip in Germ.

This is a kind of hard ſtone, lately brought into notice by its electrical properties.

This ſtone has been known in Europe ſince the year 1717 only, in which year Lemery firſt ſhewed it in the Royal Academy of Sciences at Paris. Since that time it has been made more known: and the Dutch have ſpread it every where. Moſt of them are flat on one ſide, and convex and poliſhed on the other. There are, however, likewiſe ſome rough ones like pebbles. Moſt of them are tranſparent: and the Prince de Noja, in his letter to Count Buffon, affirms, that he likewiſe had an opake one. Brunnich informs us, that the largeſt he ever ſaw is in the cabinet of Mr. Steiglitz at Leipzig: its ſize is nearly a ſquare inch, and its thickneſs two lines. Beſides this ſize it has a very remarkable quality. When you look through the two largeſt ſurfaces, which are but two lines aſunder, it appears wholly opake; but covering theſe, and looking through the ſmall ſurfaces which are near twelve lines aſunder, it is quite pellucid, which is ſuppoſed to ariſe from the peculiar texture of the ſtone, but may be owing to a want of poliſh or opacity at the larger ſurfaces. It is flat on one ſide only. We know nothing of the ſpot where the tourmalin is generated. Æpin and Bergman have written the lateſt diſſertations upon it, and mentioned all its electric qualities. Dr. Pallas ſhewed Brunnich a tourmalin, which was perfectly like the others in colour, hardneſs and tranſparency, but would not draw aſhes. Wilſon affirms, that when a tourmalin is made red hot, and kept in a violent fire for half an hour, it does not loſe its colour; but if it be cooled of a ſudden in water, it loſes its electric quality for ever.

The form of the tourmalin is a priſm of nine ſides of different breadth, moſtly truncated, and ſeldom terminating in a pyramid at each end, which is either compoſed of three pentagons, or of nine triangles.

When heated in the fire, it gives ſigns of contrary electricity on the two oppoſite ends of its priſmatic form. See Prieſtley's Electricity.

Profeſſor Bergman found ſeveral opake ſchoerls of Sweden to poſſeſs the ſame electric qualities of the tourmalin, but could not find any pellucid ones with the ſame property.

Many of theſe ſtones are not in the leaſt electric. However, on being rubbed, they become electric in their ſides, like other diaphanous gems.

They are almoſt as hard as the topaz, and ſtrike fire with ſteel.

They melt by themſelves in a ſtrong fire, though with difficulty.

With the microcoſmic ſalt they melt perfectly; but only in part with borax.

With mineral alkali, they are divided into a kind of powder.

The three mineral acids diſſolve them, when firſt reduced to a powder.

They bear a greater ſimilarity to ſchoerls than to any other ſtone: but their component parts ſhew that they may be ranged with propriety in this place, along with other precious ſtones: as the argillaceous earth is alſo the moſt prevalent in their compoſition.

The oriental tourmalins are found in the iſland of Ceylon. They are tranſparent, of a dark brown-yellow: and their ſpecific gravity is from 3,062 to 3,295.

Thoſe from Brazil are tranſparent, and for the moſt part green; but there are alſo ſome red, blue and yellow; their ſpecific gravity is from 3,075 to 3,180.

Thoſe from Tyrol are of ſo dark a green as to appear opake. Their ſpecific gravity is about 3,050. Theſe are found in beds of ſteatites and lapis ollaris among the micaceous veins, talcs, and hornblende of Schneeberg, Jurzagl, and Zillerthal, in the mountains of Tyrol.

Thoſe from the mountains of Old Caſtile in Spain are tranſparent, and have the ſame properties as the preceding.

XII. The OPAL. See OPAL.

XIII. ROCK CRYSTAL. See CRYSTAL ROCK, alſo QUARTZ.

XIV. The CAT'S EYE. See the article.

XV. The HYDROPHANES, or OCULUS MUNDI. See HYDROPHANES.

XVI. The CHALCEDONY. See the article.

XVII. The MOON STONE. Ditto.

XVIII. The ONYX. Ditto.

XIX. The CARNELION. Ditto.

XX. The SARDONYX. This is a mixture of the chalcedony and carnelion, ſometimes ſtratum-wiſe, and ſometimes confuſedly blended, or mixed together.

Of this ſtone there are two kinds. 1. That which is ſtriped with white and red ſtrata: this ſerves as well to cut in cameo, as the onyx. 2. The white with red dendritical figures. This very much reſembles that agate which is called the mocha-ſtone, but with this difference, that the figures are of a red colour in this, inſtead of black, as in the mocha-ſtone.

According to Cronſtedt, there is no real difference between the onyx, carnelion, chalcedony, ſardonyx and agate, except in ſome inexplicable degree of hardneſs.

XXI. The AGATE. This name is given to flints which are variegated with different colours, promiſcuouſly blended together; and they are eſteemed in proportion to their mixture of colours, their beauty and elegance. Hence alſo they have obtained a variety of names, moſt of which are from the Greek.

Near the bridge over the Mulda, not far from Freyberg in Saxony, a red and white agate breaks in veins. This is called coral-ſtone in Italy. The agate of Rochlitz in Saxony is the moſt celebrated, and is found in globules which have a kind of cruſt about them.

As it ever was, and muſt be very difficult to give intelligible deſcriptions of colours, we are for that reaſon quite at a loſs to underſtand the meaning of the ancients in this reſpect; but, indeed, it is of little conſequence, as we ſeem to

have

have the ſame right, under the ſame circumſtances, of inventing new names for them; and that in whatever languages we pleaſe. The following is a deſcription of ſome few varieties of thoſe which at preſent are the moſt common.

1. Brown opake agate, with black veins, and dendritical figures, which is the Egyptian pebble.

2. Of a chalcedony colour, Achates calcedoniſans.

3. Semi-tranſparent, with lines of a blackiſh-brown colour, and dendritical figures, which is the mocha-ſtone.

This is much eſteemed, and makes a valuable part of ſome collections, where it has a place chiefly for the ſake of its figures, reſembling vegetables, animals, &c. which however are often improved by art.

4. Semi-tranſparent with red dots, Gemma divi Stephani. When the points are very minute, ſo as to give the ſtone a red appearance, it is by ſome called Sardea.

5. Semi-tranſparent, with clouds of an orange colour.

6. Deep-red, or violet, and ſemi-tranſparent.

7. Of many colours, and variegated.

8. Black.

There are in Europe great quantities of moſt varieties of agates, particularly at Oberſtein in the Palatinate, where they are cut and poliſhed: but they are likewiſe found in every part of the world. According to Cronſtedt, there is not as yet more than one ſpecies of agate found in Sweden, namely, at Gaſebeck in the province of Skone, which is of a white and deep red colour.

XXII. The Labrador Stone. See the article.

PRECIPITATE, and PRECIPITATION. When a body diſſolved in a fluid is either in whole or in part made to ſeparate and fall down in the concrete ſtate, this falling down is called precipitation, and the matter thus ſeparated is called a precipitate. The form of precipitates is uſually pulverulent. We ſee from this explanation, that the terms precipitate and precipitation relate merely to the manner in which any product is obtained, and not at all to its component parts or properties. But as the effects denoted by theſe expreſſions continually occur in chemical operations, the words are much and uſefully applied.

The moſt uſual effect of precipitation is ſeen when a compound ſubſtance being ſuſpended in a ſolvent, another ſubſtance is added which unites with one of the principles of the compound, and ſeparates the other: and this being inſoluble in the fluid, falls down. See Attraction. As precipitations require the preſence of a fluid, and as moſt ſubſtances may be rendered fluid by fire, it naturally follows, that two kinds might be diſtinguiſhed, namely, in the dry and in the humid ways. Of precipitations in the dry way ſome inſtances may be ſeen in the Schemes of Electric Attraction of Bergman, p. 187, and under the article Blow-pipe. But the terms are ſeldom applied to dry operations; and all the products properly called precipitates are produced in humid proceſſes.

Since the inſolubility of the matter which falls down is a condition without which precipitation does not enſue, and is the only condition required to effect it, we might call the ſeparation of ſalts and other bodies from their ſolvents by evaporation, by this name. But this is not uſual, as the word implies a ſpeedy ſeparation. Chemiſts are accordingly habituated ſo to apply it. When a precipitation takes place ſlowly, they frequently uſe the word depoſition.

poſition. Thus the matter which falls quickly is ſaid to be precipitated; but they ſay a depoſition takes place when the change is not effected but during many hours or days.

The caſes of ſimple and compound precipitations are very perſpicuouſly treated of by Bergman, in his Eſſay on Metallic Precipitates, from the latter part of which work I ſhall extract the ſubſtance, only altering ſo much of the language as renders the explanations more peculiarly adapted to the theory of phlogiſton than to the pneumatic theory, and rendering it ſuitable to either by uſing general terms expreſſing the ſimple matter of fact.

There are different methods by which diſſolved metals may be ſeparated from their ſolvents; and the appearance and nature of thoſe precipitates are occaſionally varied in a very ſingular manner. Some of the moſt remarkable are thus enumerated by Bergman:

All metals may be precipitated by alkaline ſalts, which by their ſuperior power of attraction ſeparate them from their ſolvents; but the differences of theſe alkalis, with reſpect to their nature and preparation, produce different characters in the precipitates.

With the cauſtic fixed alkali the calces fall almoſt entirely pure, but loaded with water, and the matter of heat, which according to Bergman is expelled from the alkalis by the acid. The weight is found to be increaſed by the water, and perhaps by the matter of heat; but yet leſs than by the aerial acid, or fixed air, when preſent.

With the aerated or mild fixed alkali, by means of a double decompoſition, the aerial acid unites to moſt calces. The vegetable alkali, completely aerated, precipitates a white calx from ſalited mercury; but the mineral alkali does not poſſeſs that property, becauſe it cannot hold a ſufficient quantity of aerial acid or fixed air for that purpoſe.

The volatile alkali, which naturally contains inflammable air (See ALKALI VOLATILE), ſometimes partially reduces the precipitates: it throws down a black or white precipitate of mercury; nay, makes the orange-coloured calx white. Gold receives from this precipitant its fulminating quality. See GOLD.

The alkali, which is commonly called phlogiſticated, generally precipitates metals with an increaſe of weight, as Macquer firſt proved.

The acids frequently occaſion precipitates, from various cauſes.

By ſtronger elective attraction, ſilver, mercury, and lead are taken from the nitrous acid, by the addition of the marine or vitriolic. Theſe acids form with the metals new compounds, which are difficult of ſolution in water; they are therefore precipitated in greater or leſſer quantity, according to circumſtances.

The nitrous acid decompoſes the marine ſolutions of tin and antimony by calcining them beyond that point in which they are ſoluble by acids.

Alkalis ſaturated by acids, which are called neutral ſalts, ſometimes diſturb metallic ſolutions; either

By means of a double elective attraction: all thoſe which contain vitriolic or marine acid decompoſe ſolutions of ſilver, mercury, or lead, in nitrous acid, and precipitate the metals; or

By forming a triple combination: thus the vegetable, as well as volatile a though ſaturated with vitriolic, nitrous, or marine acid, precipitates platina fr aqua regia. If the mineral alkali forms the baſe, the neutral ſalt has no pow of this ſort.

Some metallic ſalts can decompoſe others, and precipitate their baſes. This may happen when the acid is different in the two ſalts, or, what is more ſingular, even though it be the ſame.

Solution of gold gives us an example of each of theſe two caſes. This, as is well known, is precipitated by martial vitriol, the reaſon of which was firſt explained by Bergman. Upon examining the precipitate carefully it will be eaſily underſtood: for this, when waſhed and dried, not only ſhews many reſplendent gold-coloured particles, but alſo unites with mercury by trituration, diſſolves in aqua regia, but not in marine acid alone, together with other circumſtances which evince a complete reduction of the gold. Cryſtalliſed martial vitriol contains iron not much calcined, ſo that the calx of the gold may very eaſily be reduced on the ſame principles, as if metallic iron were preſent. That this is the true foundation of the proceſs, appears alſo from this, that the weight of the diſſolved gold is preciſely recovered: it is alſo proved from this circumſtance, that pale vitriol containing iron more perfectly calcined, will not precipitate gold. It may reaſonably be enquired why the ſurrounding aqua regia leaves ſuch a precipitate untouched. The reaſon is, that the menſtruum is diluted and weakened by the quantity of water; for upon boiling it gently, ſo as to expel the water, the menſtruum recovers its ſolvent power, and takes up the precipitate. Bergman in the next place enquires into the origin of the purple precipitate.

That a ſolution of gold in aqua regia ſhould be precipitated by a ſolution of tin in the ſame menſtruum, is of more difficult explanation:—in this caſe it is the ſame menſtruum that holds the two metals diſſolved; what then is the cauſe of the change? At firſt Bergman imagined that the tin had attracted a ſuperabundance of the acid, and taken it from the gold, which being therefore deſtitute of the proper quantity muſt neceſſarily fall to the bottom: but upon employing a ſolution containing ſuperabundant aqua regia the ſame precipitate was occaſioned. The cauſe was not therefore to be ſought in the menſtruum: he therefore examined the precipitate itſelf. Its external appearance ſhews nothing like the metallic ſplendor, but altogether reſembles a calx: it is eaſily found by its weight, that it cannot conſiſt entirely of gold; and in fact chemical examination diſcovers a conſiderable quantity of tin. It cannot be diſſolved by the marine acid alone, but, upon the addition of a little nitrous acid, is eaſily taken up: triturated with mercury, it ſcarcely unites with it. Theſe properties ſeem to indicate that the gold is ſo far reduced, as to reſiſt the marine acid, unleſs aided by the nitrous; but its earthy appearance, and its habits with reſpect to mercury, evince that it is not in its complete metallic form. Bergman therefore offers the following conjectural explanation. The ſolution of tin neceſſary for this operation muſt contain the metal as ſlightly calcined as poſſible, conſiſtent with ſolubility. This is dropped into a ſolution of gold very much diluted, by which means the tin is more readily diſpoſed to become calcined in a greater degree by the action of the calx of gold, which at the ſame time approaches nearer the metallic ſtate. Neither metal can then be retained by the acid, for the one is too much calcined, and the other too far reduced: they muſt both therefore of conſequence fall to the bottom, mixed intimately together. It is probable that, in this caſe, it is the calx of tin which prevents the union with mercury.

Beſides, the metals precipitate one another after a certain order. This order is found to be the ſame in all acid menſtrua, as we have frequently had occaſion to mention.

But many irregular circumſtances occur in this matter, depending no doubt upon accidental circumſtances. The order is indeed conſtant, and never inverted;

verted; zinc prevails over iron; iron over lead; lead over tin; tin over copper; copper over ſilver; ſilver over mercury, &c.: yet it ſometimes happens that a metal, which, according to the general rule, precipitates another, in its metallic ſtate, from one ſolvent, precipitates it from another in the form of a calx; and from a third not at all. Some examples will illuſtrate this:—zinc precipitates iron from marine acid in its metallic ſtate, but from the nitrous only in the form of a calx. Perhaps the calcination which enſues in the zinc may not be ſufficient to reduce the iron, which in the latter caſe has been much more calcined; or perhaps, though leſs probably, the iron, though ſeparated in the metallic form, may have been afterwards calcined by the nitrous acid. Tin precipitated from marine acid by lead appears in the metallic form; but is not thrown down from nitrous acid; and from vinegar is precipitated in form of a calx, even by iron and zinc: lead lets fall nothing from vinegar upon the addition of iron. Theſe and other anomalies are expreſsly examined in Bergman's Treatiſe on Electric Attractions, but in this place he only remarks that a ſmall exceſs of acid is neceſſary; and that without it no precipitation begins*: but a great ſuperabundance prevents that operation, by again diſſolving the precipitate; beſides, the weights of the precipitates and the diſſolved precipitants do not correſpond.

The colours of the metallic precipitates are of conſiderable utility to be known and attended to. Bergman employed the mineral alkali, becauſe the degree of ſaturation of it with aerial acid is more conſtant. When he had occaſion for a cauſtic alkali, he prepared it by a ſmall quantity of burned lime, in a cloſe bottle; the goodneſs of it was proved by its occaſioning no precipitation in lime water. For the preparation of Pruſſian alkali, ſee that article.

Gold diſſolved in aqua regia is precipitated by cauſtic mineral alkali, almoſt black; by the aerated yellow; as alſo by the Pruſſian, unleſs ſome iron be preſent, which frequently happens. As the whole of the gold is ſcarcely ever precipitated, Bergman does not pretend to aſcertain the weights.

Neither the cauſtic nor aerated mineral alkali precipitates one half of platina, diſſolved in aqua regia; the precipitate is of an orange colour, which on drying changes to a brown. An over proportion of alkali re-diſſolves the precipitate with a more obſcure tinge; indeed the precipitation is ſo imperfect that alkali ſaturated with acid ſeems to diſſolve it. The Pruſſian alkali does not precipitate the depurated ſolution, nor even make it turbid; but heightens the colour in the ſame manner as the exceſs of alkali does.

Silver diſſolved in nitrous acid is precipitated white by aerated mineral alkali; by the cauſtic, brown; and by the Pruſſian alkali, of an obſcure yellow; by the vitriolic as well as the marine acid, white; but the former precipitate conſiſts of more diſtinct particles, which grow black more ſlightly in the light of the ſun.

Salited mercury is precipitated red, or rather ferruginous, by aerated alkali; by the cauſtic, more yellowiſh, or orange. Nitrated mercury, prepared without heat, yields a ferruginous precipitate with mineral alkali; a black with cauſtic: when prepared with heat, it yields to cauſtic alkali an orange, or reddiſh yellow precipitate: by Pruſſian alkali it is precipitated from all acids white; which, when dried, becomes of a browniſh yellow. Salited mercury is very ſparingly precipitated by this alkali. The precipitate occaſioned by Pruſſian alkali is again diſſolved, if too much alkali be uſed.

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* This was firſt obſerved by the celebrated Gahn.

It has been ſhewn already, that a white precipitate may be obtained by aerated vegetable alkali, and the cauſe of this has been explained.

Corroſive ſublimate muſt be very cautiouſly precipitated by cauſtic, as well as aerated fixed alkali; for the part ſeparated may again be diſſolved by a large quantity of water. If too much alkali be uſed, a new compound ariſes of a peculiar nature.

Nitrated lead is thrown down white by aerated, cauſtic, or Pruſſian alkali. If too much alkali be uſed, the laſt precipitate is diſſolved with a browniſh yellow colour. Vitriolated and ſalited lead is precipitated white.

Nitrated copper, which in ſolution is blue, is precipitated of a bright green by aerated fixed alkali; by the cauſtic, of a grayiſh brown, which grows reddiſh by age. By Pruſſian alkali, copper is precipitated of a greeniſh colour, which afterwards grows of a browniſh red, and upon exſiccation almoſt black. The aerial acid readily takes up a ſmall portion of copper during the precipitation, which is again depoſited by the heat of boiling.

Iron is precipitated green by the aerated fixed alkali, from vitriolic and marine acid; this precipitate becomes of a browniſh yellow, eſpecially on drying; with the cauſtic alkali it approaches more to black: in the precipitation ſome part is held in ſolution by the aerial acid, if the aerated alkali be uſed: the Pruſſian alkali yields a dark blue precipitate.

Tin is precipitated white by every alkaline ſalt, even by the Pruſſian alkali; but at length ſome blue particles, which are mixed, appear, ſo that the whole, when collected and dried, is of a light blue colour. That theſe blue particles depend upon iron is eaſily ſeen upon calcination, for they become ferruginous and obey the magnet. Bergman always found an admixture of iron in tin.

Biſmuth is precipitated white by water and alkalis, particularly the former; Pruſſian alkali throws down a yellow powder, which being mixed with blue particles, occaſioned by iron, at length appears green. This yellow ſediment eaſily diſſolves in nitrous acid.

Nickel is precipitated of a whitiſh green by fixed alkalis; by the Pruſſian alkali, of a yellow; and by exſiccation it is condenſed into a dark brown maſs.

Arſenic diſſolved in acids, which prevent too great calcination, may, to a certain degree, be precipitated white by the fixed alkali, even when phlogiſticated, but the ſediment is found ſoluble in water; yet nitrous acid, either alone or joined with the marine, generally calcines the arſenical acid, to ſuch a degree that it becomes unfit for ſeparation. Arſenic, diſſolved in marine acid, with the addition of a little nitrous acid depoſited a white ſediment; upon the addition of a large quantity of Pruſſian alkali, the ſediment was mixed with Pruſſian blue; this was diſſolved in water, and freed by frequent filtration from the blue particles, and at length, on evaporating to dryneſs, yielded a ſemi-pellucid maſs.

Cobalt diſſolved in acids is thrown down by fixed alkali, whether aerated or cauſtic, of a reddiſh blue, which colour on drying grows darker, eſpecially when the former alkali has been uſed. Pruſſian alkali throws down a powder of almoſt the ſame colour, which upon drying becomes of a reddiſh-brown.

Zinc is precipitated white by aerated and cauſtic fixed alkali, as alſo by the Pruſſian alkali; but this laſt, on drying, becomes of a citron colour. A ſmall portion of aerial acid may eaſily eſcape during the precipitation.

Antimony is precipitated white by alkalis. When the Pruſſian alkali is uſed, there are almoſt always ſome blue particles precipitated, though the regulus had been prepared without any iron. The operation muſt be cautiouſly conducted, otherwiſe ſome part may be taken up by the alkaline ſalt.

Manganeſe, which is procured by reduction from common magneſia nigra, generally renders ſolvents brown, and with aerated alkali yields a yellowiſh-brown ſediment; with the cauſtic, one ſtill darker; with the Pruſſian a powder is ſeparated, at firſt blue, then a white, the mixture of which renders the maſs a darkiſh, or rather a black-green. In order that the calx of the manganeſe may be obtained pure and white, the precipitate afforded by cauſtic alkali muſt be diſſolved in pure vinegar; for there ſtill remains a quantity of undiſſolved iron, which would be taken up by the aerial acid if preſent. This acetous ſolution contains ſcarcely any iron. That metal may alſo at firſt be ſeparated by a ſmall quantity of volatile alkali.

The common ſolution of the regulus is not perfectly precipitated by aerated alkali: and if the remaining fluid be left to evaporate ſpontaneouſly to dryneſs, grains of a metallic ſplendor are depoſited on the glaſs, which are not unlike copper. Theſe are readily, though but partially, diſſolved in nitrous acid; but upon the addition of zinc, nothing falls but the manganeſe, though at firſt it is a little reddiſh. With Pruſſian alkali, a yellow precipitate, reſembling pure manganeſe, falls, provided the ſolution has firſt depoſited the iron by ſtanding; but the recent ſolution yields a precipitate nearly the ſame as is obtained from the common regulus. The yellow ſediment is ſoluble in water.

A conſiderable difficulty always attends the deſcription of colours, becauſe the ſeveral varieties, which are almoſt innumerable, have no particular names. Colours are indeed ſubject to changes, but the ſmalleſt never occurs without ſome determinate cauſe; they ſhould therefore be carefully obſerved, for we may always learn ſomething, provided we conſider every thing with due attention.

A due conſideration of the metallic precipitates will explain many obſcurities in the ſcience of chemiſtry.

The firſt inquiry of Bergman relates to their weight. He examined only thoſe precipitates which are occaſioned by aerated mineral alkali, cauſtic alkali, and Pruſſian alkali. The reſults of many experiments were rejected, as too vague and indeterminate; but he expreſſes his hope that the reſt were better founded. However, upon reflecting how difficult it is to depurate and waſh completely the metallic ſediment, ſo that neither the alkali, the aerial acid, the water, nor any other extraneous matter ſhall adhere, he conſiders them only as collections of the firſt terms of infinite ſeries, which converge very quickly. In order to obtain the neareſt poſſible approximation, he frequently repeated the experiments in the moſt accurate manner. In the following table 100 parts of the metallic regulus are always ſuppoſed to be diſſolved.

					Dry Precip.
100 parts of	Gold	precipitated by	aerated mineral alkali	yielded	106
———	———	———	cauſtic —	—	110
———	———	———	Pruſſian —	—	
———	———	———	martial vitriol —	—	100
———	Platina,	———	aerated mineral alkali	—	34
———	———	———	cauſtic —	—	36
———	———	———	Pruſſian —	—	
———	Silver,	———	aerated mineral alkali	—	129
———	———	———	cauſtic —	—	112

				Dry Precip.
100 parts of	Silver,	precipitated by	Pruſſian alkali	145
———	———	———	ſalited	133
———	———	———	vitriolated	134
———	Mercury,	———	aerated mineral alkali	110
———	———	———	cauſtic	104
———	———	———	Pruſſian	
———	———	———	vitriolated	119
———	Lead,	———	aerated mineral alkali	132
———	———	———	cauſtic	116
———	———	———	Pruſſian	
———	———	———	vitriolated	143
———	Copper,	———	aerated mineral alkali	194
———	———	———	cauſtic	158
———	———	———	Pruſſian mineral alkali	530
———	Iron,	———	aerated mineral alkali	225
———	———	———	cauſtic	170
———	———	———	Pruſſian	590
———	Tin,	———	aerated mineral alkali	131
———	———	———	cauſtic	130
———	———	———	Pruſſian	250
———	Biſmuth,	———	aerated mineral alkali	130
———	———	———	cauſtic	125
———	———	———	Pruſſian	180
———	———	———	pure water	113
———	Nickel,	———	aerated mineral alkali	135
———	———	———	cauſtic	128
———	———	———	Pruſſian	250
———	Arſenic,	———	aerated mineral alkali	
———	———	———	cauſtic	
———	———	———	Pruſſian	180
———	Cobalt,	———	aerated mineral alkali	160
———	———	———	cauſtic	140
———	———	———	Pruſſian	142
———	Zinc,	———	aerated mineral alkali	193
———	———	———	cauſtic	161
———	———	———	Pruſſian	495
———	Antimony,	———	aerated mineral alkali	140
———	———	———	cauſtic	138
———	———	———	Pruſſian	138
———	Manganeſe,	———	aerated mineral alkali	180
———	———	———	cauſtic	168
———	———	———	Pruſſian	150

Upon comparing theſe weights, a queſtion at firſt occurs concerning the cauſe of ſuch enormous differences; and it is plain that this cauſe muſt be ſought for in the precipitates themſelves. The fixed alkali, ſaturated with aerial acid, when added to the ſolution, is taken up by the more powerful menſtruum, and the weaker is of courſe expelled, and is abſorbed by the calx, as it falls in greater or leſſer quantity according to circumſtances. That this is actually the caſe is eaſily demonſtrated :—let a bottle, containing a ſufficient quantity of nitrous acid, be accurately weighed ; let there be put into it by degrees, e. g. 132 parts of lead, precipitated by aerated alkali, and not only an effervefcence will be obſerved, which continues until the very laſt particle is diſſolved ; but when the ſolution is finiſhed a deficiency of weight is diſcovered, which amounts nearly to 21, and which is indubitably owing to the extrication of aerial acid. But 132—21=111, a weight which ſtill conſiderably exceeds that of the metal. Upon diſtillation nearly 8 of water are diſcovered ; there yet remain therefore 3, which by violent heat are increaſed by 7 ; for 132 of the calx, well calcined, yield 110. The whole increment of weight then does not depend upon the water and aerial acid. The ſame thing is evinced from the conſideration of the precipitate of lead by the cauſtic alkali, as it is evident that in this caſe there is no aerial acid ; beſides, no effervefcence accompanies the ſolution. If we ſuppoſe the quantity of water equal in both caſes, yet, even on this ſuppoſition, the whole exceſs is not accounted for, for 116—8=108. Bergman thinks it probable therefore, that the matter of heat is attached to the calx, and reaſons as follows : This matter of heat is always preſent in cauſtic alkali ; for when it is diſſolved in the ſimple acids, heat is always generated. And again : 1ſt. The increment of weight can ſcarce be conceived, without ſuppoſing an increment of matter. 2d. When the cauſtic alkali is employed, no other matter can be ſuſpected. 3d. The ſame cauſe is alſo preſent when the weight is increaſed by dry calcination. 4th. Let the heat occaſioned by the mixture of determinate portions of any acid and cauſtic alkali be marked upon a thermometer : let then an equal quantity of the ſame menſtruum be ſaturated with a metal ; afterwards, upon the addition of an equal quantity of cauſtic alkali, it will be found either that no heat is generated, or a degree very much leſs than before. Some of the matter of heat therefore is taken up and fixed *, which alſo generally makes the colours of the precipitates more obſcure, and in diſtillation with ſal ammoniac communicates to the volatile alkali the quantity that had been taken away. What has been ſaid of lead is alſo true of the other metals, a few excepted, which ſeem to take up little or no aerial acid ; theſe are tin, antimony, gold, and platina.

But ſome precipitates retain alſo a quantity of the menſtruum. Thus, corroſive ſublimate, precipitated by aerated alkali, retains a portion of marine acid, which cannot be waſhed off by water ; but by cauſtic alkali the precipitate may be obtained, either free of the acid altogether, or in a great meaſure. In this caſe, as in many others, the aerial acid ſeems to generate a triple ſalt, which is ſcarcely ſoluble. The preſence of the marine acid is eaſily diſcovered by nitrated ſilver, if the precipitate be previouſly diſſolved in pure nitrous acid. Hence we obſerve another difference in mercury precipitated from marine acid, according as aerated or cauſtic alkali has been employed : the latter precipitate, well waſhed and put into volatile alkali, is ſcarcely changed in colour ; but the former inſtantly grows white, generating a ſpecies of ſal alembroth, but containing ſo little marine acid as not to be eaſily ſoluble in water.

The calces, which retain any of their former menſtruum, generally give over on diſtillation a ſmall portion of ſublimate. The mercurial calx, juſt mentioned, expoſed to a ſufficient degree of heat, is partly reduced to crude mercury, partly

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* The increaſe of weight acquired by metals from the abſorption of vital air in calcination was leſs known and attended to at the time the great Bergman compoſed his Treatiſe on Metallic Precipitates than ſince ; otherwiſe this fact would have afforded an eaſier ſolution of the preſent difficulty, than the violent ſuppoſition of material and ponderable heat.

to mercurius dulcis, by means of its remaining marine acid. This mercurius dulcis did not exiſt in the precipitate; for in that caſe it would be eaſily diſcovered by acids, in which it is not ſoluble, and would grow black with cauſtic alkali; neither of which things takes place; it is therefore generated during the diſtillation.

The Pruſſian alkali has the ſame property with regard to ſalts and ſoluble earths, as acids, in the ſtate called phlogiſticated, poſſeſs. Its compounds with metals are of a ſaline nature, though moſtly inſoluble in water.

The excellent treatiſe of Bergman concludes with pointing out ſome of the advantages reſulting from the examination of metallic precipitates.

It is evident, that by a more intimate acquaintance with theſe precipitates, the chemical theory of the operation will be better underſtood.

Hence we may diſcover their more uſeful and remarkable properties. Every one knows that aurum fulminans, the mineral purple, and other encauſtic pigments, by which the colours of gems may be imitated, have been derived from this ſource.

A foundation is by this means eſtabliſhed for the art of aſſaying by the humid way, from the bare knowledge of the weights. It may be objected, that the doctrine of the weights is very fallacious; that they vary in the different precipitates; that by imperfect precipitation ſomething remains in the liquor; and that extraneous matters ſometimes are mixed with them. All this is true; yet if the mode of operation be always the ſame, the reſults of the experiments muſt be conſtant. Let us ſuppoſe that a quantity of metal, precipitated in a certain manner, makes a weight; if that ſame manner be exactly employed, we may fairly conclude that a quantity of precipitate, occurring in any caſe, is correſpondent to a quantity of perfect metal; although in the fundamental experiment either the precipitation is incomplete, or ſome extraneous matter is preſent. If all the circumſtances which occaſion increaſe or deficiency be carefully attended to, the concluſion will remain unimpeached: let the method therefore be accurately determined, and there will be no danger of fallacy.

Hence the nature of metals is illuſtrated. Platina, nickel, cobalt, and manganeſe, are ſuſpected by ſome perſons to derive their origin from a mixture of other metals. But if iron neceſſarily enters into the compoſition of platina, when this is diſſolved in aqua regia it ſhould produce a blue upon the addition of Pruſſian alkali; and this is the caſe in fact when common platina is employed, but not when it is rightly depurated. See Platina.

If iron, adhering very obſtinately to nickel, formed a great part of it, the precipitates obtained from it by alkalis could not differ from martial precipitates ſo much as they do, in colour, weight, and other properties.

The ſame is true of cobalt and manganeſe. The regulus obtained from black manganeſe contains about 0,08 of iron: let us ſee how this affects the mixture.

One hundred parts diſſolved in an acid menſtruum yield to phlogiſticated alkali a powder, conſiſting partly of blue, partly of browniſh-yellow particles, which is equal in weight to 150lb.; but 8lb. of iron yield 48 of Pruſſian blue, nearly $\frac{1}{3}$ of the whole maſs: hence it follows, that 100 parts of pure manganeſe yield to phlogiſticated alkali ſcarcely 111, i. e. nearly ſix times leſs than an equal weight of iron.

Laſtly, Bergman remarks, it may by this means perhaps be poſſible to determine the unequal quantities of phlogiſton in different metals; for a given weight of precipitating metal does not yield an equal quantity of precipitate: thus for example, copper is able to precipitate from nitrous acid four times its own weight of ſilver.

This object is more completely developed in his Treatiſe on the Quantities of Phlogiſton in Metals, of which we have no Engliſh tranſlation *. In the following account I ſhall not ſo far depart from the author as to ſubſtitute the words baſis of vital air inſtead of phlogiſton, which is all the converſion this valuable maſs of facts requires, to adapt it to the antiphlogiſtian theory. In its preſent form, indeed, the agency of vital air in the calcination is overlooked. But if the great author had lived longer, he would doubtleſs have added a modification of this doctrine to the other improvements which the ſciences have unhappily loſt by his death.

The general facts relating to the quantities of metals precipitated by metals are given by him in the form of equations. It may perhaps be more convenient to readers in general to ſee them in words at length.

There are ſix things to be conſidered when this effect is intended to happen. 1. The metal already in ſolution. 2. The quantity of ſolvent which ſuſtains it. 3. The quantity of phlogiſton loſt (or vital air acquired) by the metal. And 4. The metal preſented, or the precipitant. 5. The quantity of ſolvent required to take up a portion of this metal equal to that held in ſolution. 6. The phlogiſton it contains (or vital air it would acquire by ſolution). Then,

1. If the weights of ſolvent (2 and 5) be equal;

And alſo the quantities of phlogiſton (3 and 6) there will be no difficulty in the precipitation. For the ſolvent is capable of diſſolving as much of the one metal as of the other, and the precipitate can take as much phlogiſton from the precipitant as its reduction demands.

Again: if the quantity of phlogiſton in the precipitant exceed that required for the reduction of the precipitate, there will be no obſtacle to the effect.

But if the phlogiſton of the precipitant be leſs than the precipitate requires, a part only of this laſt will fall down; unleſs the precipitation be aided by ſome cauſe of a different nature from thoſe here attended to.

2. If the weight of ſolvent required to ſuſtain the precipitant be leſs than would ſuſtain an equal portion of the metal intended to be thrown down, the effect with regard to phlogiſton will be the ſame as in No. 1. but the obſtacles will be leſs.

3. If the weight of ſolvent, required as in the laſt caſe, be greater than would ſuſtain the metal intended to be thrown down, the whole of the precipitant will not be diſſolved, and the precipitate will not be entirely ſeparated, unleſs the phlogiſton of the precipitant ſo much exceeds that required by the precipitate, as that the portion of the precipitant diſſolved may ſupply the whole requiſite quantity of that principle.

This excellent chemiſt then proceeded to apply theſe general principles to the teſt of experiment. Among the ſeveral proceſſes, he choſe to inſtitute two ſets. In the firſt, ſilver was taken as the term of compariſon, becauſe it is precipitated from nitrous acid by all the metals but gold and platina: and in the ſecond ſet he made uſe of zinc, which is a precipitant to them all.

One hundred docimaſtic pounds of ſilver were diſſolved in nitrous acid with as little exceſs of acid as poſſible. For all metallic ſalts redden the tincture of turnſole, and cannot be deprived of this ſmall exceſs without decompoſing the

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* There is a French Tranſlation in the Journal de Phyſique, xxii. 109.

ſalts. To the ſolution was added twice the quantity of diſtilled water, and then mercury was added at ſeveral times. Various cryſtallizations of the arbor Dianæ were afforded, as the proportions of the mercury varied. In fact, where the mercury was moſt abundant in proportion to the ſilver to be precipitated, the vegetations were more ſlowly produced; but were more beautiful, more brilliant, ſtronger, and ſometimes cryſtallized in priſms. The mercury when thrown into the ſolution of ſilver hardens; its ſurface becomes irregular, and at laſt it puts forth branches which increaſe by ſlow degrees. Theſe branches, collected, waſhed, and dried, weighed 455 pounds. The whole of the mercury added was 490 lbs. Conſequently there were 455—100=355 pounds of mercury amalgamated with the ſilver, and 490—355=135 pounds of mercury diſſolved in the acid.

Two hundred and thirty-four lbs. of lead were required to precipitate one hundred of ſilver. The plate of lead ſoon becomes black on immerſion, and is quickly covered with ſmall cryſtalline needles of ſilver. The laſt portions are thrown down very ſlowly, if recourſe be not had to heat. The precipitate being collected always weighs eight or ten pounds more than the quintal, evidently from ſome of the lead which falls in the calciform ſtate.

A plate of very clean copper, weighing 375 pounds, was very quickly covered with a cryſtalline cruſt of ſilver, after it had been plunged into the ſolution. When all the ſilver had fallen down, the plate of copper well waſhed was found to have loſt thirty-two pounds. The precipitate of ſilver proved to be exactly the quintal.

With the intention of aſcertaining the different force of ſolvents, Bergman added copper to a vitriolic ſolution of ſilver. Thirty pounds were ſufficient to precipitate the quintal of ſilver. Whence he remarks, that the nitrous acid poſſeſſes a greater avidity for phlogiſton than the vitriolic. The pneumatic chemiſt would ſay, that the one acid is more eaſily decompoſed, and made to afford vital air to the calx, than the other.

Iron exhibited a very peculiar character. In general no precipitation took place by adding iron to the nitrous ſolution, and the facts are highly intereſting and remarkable. But as Bergman has not offered any explanation, and other experiments appear to be wanting, I ſhall not here enter into any detail *.

Silver diſſolved in the vitriolic acid is precipitated very ſpeedily and well by iron. The iron plate loſt thirty-nine pounds in precipitating one hundred pounds of ſilver.

Thoſe metals which the vitriolic acid diſſolves readily are more eaſily precipitated than from a ſimilar nitrous ſolution. This fact ought to be kept in mind in the humid method of analyſis.

Tin in leaves precipitates ſilver very ſpeedily from the nitrous acid. It has even the cryſtalline form; but the fluid ſpeedily becomes black, and frequently continues ſo for four-and-twenty hours. Eighty-eight pounds of tin precipitated the quintal of ſilver at a moderate heat; but the precipitate well waſhed amounted to two hundred and fifteen pounds. This increaſe of weight aroſe from the calx of tin which fell down with the precipitate of ſilver. It was contaminated by a blackiſh matter, probably an impurity.

Biſmuth at the firſt inſtant precipitates ſilver very well; but towards the end it is very difficult to aſcertain the neceſſary quantity. A ſolution of biſmuth perfectly ſaturated cannot ſupport either heat or dilution with water, without depoſiting a white powder which mixes with the precipitate, and cannot be ſeparated

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* Keir in the Phil. Tranſ. for 1780 has thrown ſome light on this object, and promiſes to conſider it farther.

parated but with extreme difficulty. The precipitate of ſilver is ſo ſpungy that it abſorbs the whole of the fluid; ſo that towards the end there is not enough to diſſolve the biſmuth, and no diſtinct obſervation of the effect can be made. When this difficulty began to preſent itſelf, Bergman endeavoured to expreſs the fluid from the ſediment between two plates of glaſs. Out of this fluid he precipitated the biſmuth by the addition of water; and after decantation, the ſilver was ſeparated by marine acid. Hence, from the weight of ſilver in the ſaline ſtate, he acquired a knowledge of the quantity which had been precipitated by the known weight of biſmuth. By this expedient he found, that the thermometer being at 15° (of Celſius, which anſwers to 59 of Fahrenheit) one hundred and ſeventy-four pounds were required. When the precipitate was waſhed, the water was rendered turbid, and ſeemed to carry off ſome portions of biſmuth. The whole ſediment weighed one hundred and eighty pounds. The firſt parcels of biſmuth, inſtead of becoming black upon immerſion, became white, and were covered with ſmall brilliant cryſtallizations of ſilver. Towards the middle it is diſſolved without loſing its lamellated ſtructure, and aſſumes a whitiſh earthy aſpect, ſeldom of a metallic appearance; but towards the end, the pieces which are continued to be added become immediately black.

Nickel, as ſoon as it is put into the ſolution of ſilver, turns the fluid green, and ſome precipitation ſeems to take place; for metallic and brilliant ſpots, though few and ſlowly produced, are ſeen upon the ſurface. The operation was not haſtened by exceſs of acid, and a digeſting heat. It is abſolutely neceſſary to reduce the ſemi-metal to a fine powder; a manipulation which is unneceſſary for all the other metals, regulus of arſenic excepted. It is very difficult to make an experiment with accuracy, when a precipitate is to be thrown down, by the gradual addition of a pulverulent matter. Sixty-four pounds of nickel are required to throw down one quintal of ſilver. The precipitate is full of ſmall cryſtals, and contaminated by a brown powder. It weighed in the whole one hundred and ſixteen pounds.

Of all the metals, arſenic precipitates ſilver with the greateſt difficulty. It muſt be pulverized; for, if it be in fragments, its ſurface becomes white, and the interior part is not attacked, and it would be to no purpoſe to employ either an exceſs of acid or evaporation to dry this. Ninety-two pounds precipitate the quintal of ſilver. The precipitate waſhed and dried amounted to one hundred and forty pounds; the increaſe being owing to the calx of arſenic.

The quintal of ſilver is precipitated by thirty-nine pounds of cobalt, in the cryſtalline form, without the aſſiſtance either of heat or pulveriſing. The ſolution immediately becomes red.

Zinc is blackened as ſoon as it is immerſed in the ſolution of ſilver. It becomes covered with an aſh-coloured moſs, which in a few moments acquires the brilliancy of ſilver. Fifty-five pounds are ſufficient for the precipitation. The introduction of this precipitant produces heat.

The precipitation is equally well effected by the regulus of antimony. The precipitate has even a peculiar appearance. The revived metal reſembles twiſted fragments of ſilver leaf. The ſolution will bear diluting, but not heat, which prevents the laſt portions of ſilver from eaſily ſeparating. About eighty-three pounds of the precipitant are required, and the precipitate weighed two hundred pounds, viz. double the weight of the ſilver employed. This increaſe aroſe from the calx of antimony, which was almoſt totally precipitated; for the fluid ſcarcely contained a few pounds.

Manganeſe becomes immediately covered with a pellicle of ſilver. A powder was produced during this operation, partly black and partly greeniſh, which weighed eleven pounds. Forty-four pounds of the precipitant were required, and the precipitate was more ſolid than with the other metals; it was yellowiſh.

From the preceding experiments, the ſeveral metals are comparable with each other, in the character of precipitants of a common ſubſtance, namely, ſilver. In the following experiments, they are comparable in another way, viz. as precipitates, by the common ſubſtance zinc.

A quintal of pure gold diſſolved in aqua regia, with the leaſt poſſible exceſs of acid, required two hundred and ſeventeen pounds of zinc for its precipitation.

A like quantity of gold was precipitated by three hundred and one pounds of Engliſh tin. Sixty-ſix pounds of gold were completely revived; and one hundred and ſixty pounds of a black purple were obtained. The reſt of the liquid had ſtill a purple tinge; but it was not decompoſed at a moderate heat, by the addition of a new quantity of tin. One hundred and fifty-eight pounds of zinc precipitated a powder inclining to purple, which when waſhed and dried weighed two hundred and twelve pounds.

A quintal of crude platina was diſſolved in aqua regia until the menſtruum would take up no more at a boiling heat. It required, however, four hundred and ſixteen pounds of zinc to bring the ſolution to complete ſaturation. The fluid acquires a blood colour, and is filled with black particles which ſeparate with a lively efferveſcence. After this inteſtine commotion has ſubſided, a black powder falls, which when waſhed and dried weighs ſeventy-ſeven pounds. The remaining liquor is yellowiſh, and affords ſmall cryſtalline grains by evaporation, eſpecially if a minute portion of vegetable alkali be added. The black powder urged by the flame, before the blow-pipe on charcoal, firſt emits white fumes, and then reſumes the metallic brilliancy, not perfectly white, but grayiſh. It is not magnetical, either before or after this application of heat.

The phenomena of zinc and ſilver have already been deſcribed.

One hundred pounds of mercury require forty-four pounds of zinc to precipitate them from the nitrous acid.

The quintal of lead diſſolved in the ſame acid, is precipitated by twenty-ſix pounds of zinc. That which falls at a moderate heat poſſeſſes the metallic aſpect at firſt, and is even cryſtallized; but ſoon afterwards it becomes converted into a white powder. By the heat of ebullition, a calx only is obtained, which when waſhed and dried weighs one hundred and twenty-four pounds.

One hundred and ſixty-four pounds of zinc precipitate one hundred of copper diſſolved in the nitrous acid. The ſolution, which is at firſt blue, becomes afterwards green. Beſides the copper in the metallic ſtate, a powder is precipitated, partly white, and partly greeniſh. The whole precipitate weighs two hundred and eleven pounds.

Thirty-eight pounds of zinc precipitate twenty-ſix of copper, from a quintal of blue vitriol.

Iron diſſolved in the nitrous acid affords, upon the addition of zinc, nothing but a mere calx, the ſame as would have ſeparated ſpontaneouſly, ſo that it is impoſſible to aſcertain any decided proportion.

One quintal of green vitriol put into a cloſed matraſs, and without any heat, to prevent the calcination of the precipitate, let fall nothing but a ſmall quantity of ochreous ſediment, and the ſemi-metal was not diminiſhed at the end of eight days.

Sixty-eight pounds of zinc are required to precipitate one quintal of tin diſſolved in aqua regia. The precipitate has not the metallic aſpect. It is a white calx, and weighs one hundred and forty-nine pounds. Forty-nine pounds of zinc precipitate one hundred of biſmuth diſſolved in the nitrous acid. At a moderate heat it has the metallic form; but at a ſuperior temperature, a calx only is obtained, which weighs one hundred and thirty-three pounds.

A quintal of regulus of nickel diſſolved in nitrous acid let fall eighty pounds of a black matter, which was almoſt entirely arſenic in the reguline ſtate. Fifty-four pounds of zinc are required for this purpoſe. By a longer digeſtion with this ſemi-metal, nothing more is ſeparated but a powder of a greeniſh white, which is a mixture of the calces of zinc and nickel. The reſt of the ſolution remains as perfectly green as before. It appears therefore, that the arſenic which ſtill remains in the firſt regulus of nickel may be ſeparated better in this way than by repeated calcinations.

Zinc immerſed in a ſolution of a quintal of regulus of arſenic in aqua regia, precipitated at firſt nothing but ſome blackiſh particles, which became white during digeſtion, and increaſed in quantity by the addition of more white powder. The weight of the precipitate was one hundred and twenty-three pounds, and the loſs of the precipitant one hundred and twenty-ſix.

Cobalt lets fall by the addition of zinc aſſiſted by a digeſting heat, a powder which weighs thirty-one pounds. The colour of the ſolution remains unchanged, and the weight of the zinc is very little altered, though the evaporation be carried repeatedly to dryneſs.

The ſolution of a quintal of regulus of antimony in aqua regia is precipitated by ſeventy pounds of zinc. The antimony is recovered in the form of a white powder, and the ſolution cannot be had very clear, but by means of exceſs of acid. The precipitate is more or leſs charged with calx of zinc, according to the intenſeneſs of the heat.

Manganeſe lets fall the foreign ſubſtances which may be united with it more or leſs readily than iron, nickel, and cobalt. The piece of zinc becomes red, if copper be preſent, though in ſmall proportion, and this foreign metal may be better precipitated in this than in any other way. A green and white powder is depoſited, which phenomenon has already been noticed in copper alone.

The important conſequences deduced by Bergman from the preceding experiments are as follow:

The metals adhere to the different acids in different degrees of dephlogiſtication. For example, one hundred pounds of ſilver diſſolved in the nitrous acid require thirty-two of copper for their reduction, whereas in the vitriolic we have ſeen, that no more than thirty of copper are neceſſary. Again, one hundred pounds of copper in the vitriolic acid require no more than one hundred and forty-ſix of zinc, but in the nitrous acid, one hundred and ſixty-four. Again, twenty-three pounds of copper precipitate the quintal of mercury from nitrous acid, but in the marine acid, ſixteen pounds are ſufficient. Whence it may be concluded, that the nitrous acid dephlogiſticates, or calcines the metals to a high degree; the vitriolic acid ſomewhat leſs, and the marine ſtill leſs.

Since the ſolutions were made with the leaſt poſſible exceſs of acid, it muſt follow, from the weights of the precipitant and the precipitate, that the reſpective quantities of phlogiſton parted with by equal weights of the metals during ſolution, will be inverſely proportioned to thoſe weights. Whence if the quantity of phlogiſton thus determined be expreſſed by the number 100, for the centenary of ſilver; the quantity contained in mercury will be 74; in lead 43; in copper 312; in iron 256; in tin 114; in biſmuth 57; in nickel 156; in arſenic 109; in cobalt 270; in zinc 182; in antimony 120; and in mangaueſe 227.

Theſe deductions are made from the precipitates by ſilver. In order to compare them with the experiments wherein zinc was the common meaſure, the quantity of phlogiſton in that metallic ſubſtance muſt be aſſumed to be 182, conformably to the preceding deductions. From this calculation the quantities will be, for the quintal of gold 394; of platina 756; of mercury 80; of lead 47; of copper 292; of biſmuth 64; and of antimony 127. The inconſiderable differences between theſe numerical quantities require to be examined by new experiments. Among theſe facts, Bergman conſiders the experiments with ſilver as moſt worthy of confidence, becauſe a ſingle grain of ſea ſalt immediately ſhews whether the whole of the ſilver has been precipitated, and the diſſolved ſilver does not loſe its character and other properties.

By the application of the principles eſtabliſhed at the beginning of this extract, relative to the ſilver conſidered as a precipitate, it is obſervable that the weight of ſolvent required to diſſolve one hundred parts of the precipitant, does in no inſtance prove accurately equal to that which has ſuſpended the ſame quantity of metal which affords the precipitate. The quantity of ſolvent for equal portions of lead and of mercury is greater than for ſilver; but for copper, iron, tin, (biſmuth) nickel, arſenic, cobalt, zinc, and maganeſe, it is leſs. Zinc conſidered as a precipitant likewiſe affords no examples wherein theſe quantities are equal. For platina, iron, and antimony, the quantity of ſolvent for the precipitant is greater than for an equal portion of the precipitate; but in all the other inſtances it is leſs.

Bergman ſuſpects, not without motives, that the quantity of ſolvent required for the precipitate being greater, and the quantity of phlogiſton required to be imparted by the precipitant, being either equal to or greater than that required by the precipitate, will be the conſequence of a more abundant ſolution of the precipitant than is neceſſary to reduce the metal which is precipitated. If this ſuſpicion be real in all ſimilar caſes, it will affect the ground of theſe calculations. A ſcrupulous attention to the phenomena may probably explain this difficulty. Every ſolution of metal is accompanied with the development of an uniform fluid, which eſcapes with effervеſcence; but its precipitation when the ſolution is ſaturated does not exhibit this phenomenon; or at leaſt the bubbles of air which appear are very ſmall and ſeldom obſerved. Iron, which is eaſily attacked by all ſolvents, remains unaltered for many weeks in the nitrous ſolutions of lead and ſilver. Bergman has few doubts with regard to the precipitations of ſilver, becauſe they were well made, and all the phlogiſton is preſerved; but thoſe in which zinc is the agent are not entitled to the ſame confidence. For in ſome, the point of ſaturation is difficultly obſerved; in others, effervеſcence appears; and laſtly, in others the precipitate and precipitant unite. The next paragraph but one ſhews how it happens, when the menſtruum which has diſſolved the firſt metal is not ſufficient to diſſolve the requiſite quantity of the ſecond, or when the precipitating phlogiſton is inſufficient, that the reduction is not completely made.

Moſt of the precipitated metals poſſeſs the metallic aſpect. In this caſe they are always cryſtallized. But it ſometimes happens that the phlogiſton received in the humid way adheres ſo ſlightly, that it readily quits them without any remarkable

able heat. Such are lead, biſmuth, arſenic, and antimony; and what is more remarkable, it ſometimes quits them, before the metal has arrived at the bottom of the veſſel. Tin in particular exhibits this remarkable fact.

The compariſon of the weights ſhews in the moſt poſitive manner, that it is not ſeldom that a portion of the precipitant falls down likewiſe in the ſtate of calx, which ſometimes ariſes from the want of phlogiſton, or of ſolvent. The phlogiſton of a quintal of lead, for example, being only 45, there will be 234 pounds of this metal required to reduce a ſingle quintal of ſilver: but 234 pounds of lead require a much greater quantity of nitrous acid for their ſolution than 100 pounds of ſilver; and in order that a ſufficient quantity of phlogiſton may be afforded, it is neceſſary that the calcined lead ſhould be precipitated from this defective quantity of menſtruum by the metallic lead which is afterwards added.

In other caſes the two metallic calces unite, and fall down in the moſt intimate ſtate of union; ſuch are thoſe of copper and zinc, tin and gold.

Moſt of the precipitants become firſt black, then are briſtled over with ſmall aſh-coloured needles, which ſpeedily aſſume the metallic aſpect. Theſe are the different degrees of revivification.

From the preceding ſeries of experiments, Bergman deduces the affinity of the metals with phlogiſton to be in the following order: platina, gold, copper, cobalt, iron, manganeſe, zinc, nickel, antimony, tin, arſenic, ſilver, mercury, biſmuth, and lead. It may here be remarked, that this is not the order of chemical attraction, but an order relative to the quantities of this ſuppoſed principle, which each metal loſes as the precipitant of zinc, or takes when precipitated by ſilver. That the chemical attractions have not yet been ſhewn to bear any direct relation to the quantities of two principles united to a certain point of ſaturation, is explained under the article ATTRACTION. If mature reflection be had on the different ſtages of calcination of metals, it will be ſeen, that though this great work of Bergman has furniſhed us with many admirable concluſions, much yet remains to be done, both in the way of experiment and the explanation of facts, before this ſubject will be nearly exhauſted.

In the antiphlogiſtic theory, the transfer of the baſe of vital air, or the oxygenous principle, from one metal to another, according to their reſpective attractions, will explain all the preceding effects without the aſſiſtance of phlogiſton. M. Lavoiſier has put the reſult of Bergman's experiments into another form, to expreſs the quantity of oxygene, or baſe of vital air, required to diſſolve 100 grains of each of the metals. For by his own experiments he finds that mercury in the quantity of 100 grains acquires eight grains by ſolution and precipitation in the ſtate of calx. Now the quantities of oxygene will be reſpectively in the ſame inverſe proportion of the weight of the precipitates, as Bergman before deduced the quantities of phlogiſton to be. Whence he computed the following table:

Metals.		*Oxigenous principle.*	
		Gr.	For ſolution merely.
100 grs. of Platina	—	81,690	
Gold	—	43,612	
Iron	—	27 37	
Copper	—	36,000	15,85
Cobalt	—	29,190	
Manganeſe	—	21,176	

Metals.		Oxigenous principle.	
		Gr.	For ſolution merely.
100 grs. of Zinc	—	19,637	
Nickel	—	14,721	
Reg. of ant.	—	13,746	22,383
Tin	—	14	23,555
Reg. of arſ.	—	11,739	24,743
Silver	—	10,800	
Biſmuth	—	9,622	
Mercury	—	8,000	
Lead	—	4,470	14,190

PRECIPITATE (BLACK AND ROSE-COLOURED). Lemeri, who mentions many precipitates of mercury of different colours, ſays, that if a ſolution of mercury in acid of nitre be precipitated by urine, inſtead of a ſolution of common ſalt, a roſe-coloured precipitate of mercury will be formed; and that if afterwards ſome fixed or volatile alkali be added to the liquor from which the roſe-coloured precipitate has been formed, another precipitate which is black will be obtained.

The roſe-coloured precipitate conſiſts of mercury united with the phoſphoric acid, and the black appears to be mercury nearly reduced. This laſt muſt be moſt abundant, where the mercurial ſolution has been made by heat. See MERCURY, p. 486.

PRECIPITATE (GREEN); AND PRECIPITATE (BLACK); OR VIOLET-COLOURED, OF MERCURY. Some authors, particularly Lemeri, give proceſſes for other preparations of mercury, which have been employed as remedies, and which are improperly called precipitates. Such is green precipitate, which is a mixture of four parts of mercury and one part of copper, diſſolved ſeparately in the nitrous acid, and treated as in the proceſs for making red precipitate; afterwards, partly diſſolved a ſecond time by being digeſted with vinegar; and laſtly, reduced by evaporation to a dry conſiſtence. Such alſo is the preparation called by Lemeri violet mercury, or black mercurial panacea, or black precipitate, which is an artificial cinnabar overcharged with ſulphur, mixed with ſal ammoniac, and prepared by a very long and laborious proceſs: but as theſe preparations have been made only for the uſe of medicine, and have fallen into diſrepute, we ſhall not ſay any more of them, excepting that they are ſingular mixtures, accompanied with many unforeſeen appearances, which could not be explained without further examination and particular diſſertations.

PRECIPITATE PER SE. This preparation of mercury is very improperly called a precipitate; becauſe it is not ſeparated from one ſubſtance by means of another ſubſtance, as all true precipitates are, but is only mercury reduced to a red powder by calcination.

To make this preparation, three or four ounces of mercury are put into a flat-bottomed glaſs matraſs, the neck of which is very long, and the opening of a capillary ſize. This matraſs, the belly of which ought not to be entirely full of mercury, is to be placed in a ſand bath, and heated till the bottom of the veſſel containing the ſand be red-hot. This heat is to be continued during two or three months. The mercury gradually loſes its luſtre, and part of it is converted into a red powder, which does not mix with the remaining fluid mercury, but floats upon the ſurface of the mercury; or adheres to the ſides of the veſſel. The operation may be ſhortened by uſing a greater number of matraſſes, all which may be placed in the ſame bath. When enough of this red powder is obtained, it is to be collected and ſeparated from the remaining fluid mercury. This is called precipitate per ſe, or by itſelf, or red precipitated mercury without addition.

This preparation of mercury we have received from the alchemiſts, who ſpared no pains to change mercury and to fix it. They received great hopes from the change of colour, the want of fluidity, and the diminution of volatility which the mercury ſuffers by this operation. Although the mercury is much diſguiſed by theſe changes, yet it is not greatly altered, becauſe it may be reduced to fluid mercury by heat without addition. It is a combination of mercury with the vital air of the atmoſphere.

PRECIPITATE (RED). If a ſolution of mercury in nitrous acid be reduced to dryneſs by evaporation, and the mercurial nitre thence formed be put into an open matraſs ſet in a ſand-bath, with a fire gradually increaſing, the nitrous acid will diſengage itſelf from the mercury, and evaporate in a red vapour. While the acid evaporates, the ſaline mercurial maſs loſes its original whiteneſs, becomes yellow, then orange, and laſtly red.

This red matter, when ſeparated from the matraſs (which muſt be broken for that purpoſe) and pulveriſed in a glaſs-mortar, is the red precipitate as it is improperly called; it not being a precipitate, but a mercurial calx from which the greateſt part of the acid has been expelled by the fire, without the application of any intermediate ſubſtance.

The acid is decompoſed. Its azotic part flies off, and the vital air remains in combination with the mercury. This precipitate, therefore, when well made, does not differ from the precipitate per ſe.

PRECIPITATE (YELLOW). As chemiſts have given many different forms to mercury, to adapt it to medicinal uſes and to chemical proceſſes; ſo they have made various precipitates of it, and have given the name of precipitate to other mercurial preparations, which in fact are not precipitates. Theſe are chiefly denominated from their colours, without adding any epithet to ſhew that they are mercurial. Thus, white precipitate, yellow precipitate, red precipitate, &c. are preparations of mercury. Yellow precipitate is mercury diſſolved by vitriolic acid, from which it is afterwards ſeparated by addition of water alone; it is then in form of a yellow powder. See TURBITH MINERAL.

PRECIPITATE (WHITE). This is mercury ſeparated from nitrous acid by marine acid, with which it then unites. White precipitate is made by pouring a ſolution of common ſalt in diſtilled water into a ſolution of mercury in nitrous acid, till no more precipitate falls. When the ſediment is collected at bottom, the ſupernatant liquor is to be decanted, and the precipitate is to be waſhed ſeveral times with diſtilled water, and then dried.

This precipitate of mercury is one of thoſe called compound. It is a combination of mercury with the acid of common ſalt; for in this operation, as well as in the precipitation of the corneous metals, the metallic matter is only ſeparated from the nitrous acid by means of the combination it forms with the marine acid. In this precipitation, then, the phenomena are ſimilar to thoſe which happen in the formation of luna cornea and plumbum corneum. 1. White precipitate may be made by pure marine acid. 2. When it is made by common ſalt, or other ſalt containing marine acid, two decompoſitions happen, and two new combinations are formed. The nitrous acid, which was originally united with the mercury, combines with the ſubſtance that was united with the marine acid, and forms a new nitrous ſalt, which remains diſſolved in the liquor. When common ſalt is employed, cubic nitre is formed. If marine ſalt with an earthy baſis is uſed, the liquor after the precipitation contains a nitre with earthy baſis. Upon this ſubject, ſee the article AFFINITY. 3. All the mercury, though entirely ſeparated from nitrous acid, and united with marine acid, is not precipitated on the preſent occaſion, becauſe it is reduced to a ſaline compound eſſentially ſoluble in water; and conſequently the liquor contains as much of it as it can diſſolve, and another part of it is diſſolved by the water employed to waſh it.

Lemeri gives another proceſs for making a white precipitate, which conſiſts in diſſolving four ounces of ſal ammoniac in a pound of water; to which is to be added an equal quantity of corroſive ſublimate; all which could not be entirely diſſolved alone in that quantity of water, but may by means of the ſal ammoniac. See SUBLIMATE (CORROSIVE) and TINCTURE OF MERCURY. Into this ſolution liquid fixed alkali is to be added till no more is precipitated. The precipitate is very white, and it has been accordingly called white precipitate by ſeveral chemiſts: but it ought not to be confounded with the white precipitate formed by adding marine acid or common ſalt to a ſolution of mercury in nitrous acid; for they are evidently very different.

PRECIPITATE OF GOLD BY TIN, OR PURPLE POWDER OF CASSIUS. This precipitate of gold may be made by ſeveral methods: but which of theſe is the beſt, has not yet been decided. The cauſe of this uncertainty is, that the preparation requires delicate management, and is uncertain in its reſult; the beauty of the colour ſeeming to depend on ſome ſmall circumſtances not yet diſcovered; for we find that the colour of the powder obtained frequently varies, notwithſtanding the proceſſes ſeem to have been the ſame. Macquer tried ſeveral methods. The following is that which beſt ſucceeded with him, and is nearly the ſame as that deſcribed by Mr. Gellert in his Metallurgic Chemiſtry.

Make an aqua regia with two parts of ſpirit of nitre and one part of ſpirit of ſalt; dilute this acid with an equal quantity of diſtilled water; add to it a ſmall piece of Malacca tin, and let it be diſſolved without heat. If the weather be cold, the time employed in this ſolution will be long; but this is rather an advantage than an injury. When this piece of tin is entirely diſſolved, add another, and let it be diſſolved in the ſame manner; continue to add more pieces of tin, one at a time, till the liquor has acquired a yellow colour, and almoſt ceaſes to act upon the tin; then decant the liquor from the remaining piece of metal.

Alſo diſſolve gold of twenty-four carats in aqua regia compoſed of three parts of ſpirit of nitre, and one part of ſpirit of ſalt. This ſolution may be accelerated by the heat of a ſand-bath.

Dilute the ſolution of tin in a hundred times its quantity of diſtilled water. Try your ſolutions in the following manner: take a ſmall quantity of the diluted ſolution of tin; divide it into two parts; to one of which add a known quantity of diſtilled water: to each of theſe proportions of the ſolution of tin add a drop of the ſolution of gold, by which they will acquire a red purple colour: obſerve which of the colours of the two ſolutions is the fineſt, and keep to that degree of dilution for the reſt of the ſolution of tin: to the ſolution of tin thus diluted add ſuch a quantity of the ſolution of gold, that there ſhall be in the mixture two parts of the former metal to one of the latter: ſtir well the mixture (which ought to be made in a large glaſs veſſel) with a glaſs rod. The whole will acquire the colour of red wine, and a ſediment will gradually be depoſited of the ſame colour, while the liquor will become clear. Then pour into this clear liquor ſome drops of the ſolution of tin, and obſerve if any more gold is precipitated: when the liquor is very clear, decant it gently from the ſediment, which is to be well waſhed with pure diſtilled water. This is precipitate of gold, or the purple powder diſcovered by Caſſius. It is a valuable preparation, becauſe it is the only one known capable of giving a red purple or crimſon colour to glaſs, enamel and porcelain. When it is to be uſed, it muſt be well mixed, and ground with a fuſible glaſs, as Venice glaſs; and this mixture is to be expoſed to the degree of heat neceſſary for melting the glaſs. If a coloured glaſs or artificial ruby be required to be made, ſo large a quantity of glaſs is to be added to the mixture, that the gold ſhall not deſtroy its tranſparency: but for enamel painting a ſmaller quantity of glaſs is required, that the colour may be intenſe. The particular proportions cannot be aſcertained, becauſe the intenſity of the colour given by the gold is very variable.

The precipitate itſelf is an intimate combination of the calces of gold and tin.

In the Novi Commentarii of the Royal Society of Gottingen for the year 1774, there is an account of experiments made to inveſtigate the cauſes of the uncertainty of ſucceſs in preparing the purple precipitate of Caſſius, by Jean. Chriſt. Polyc. Exleben. According to this author, a principle requiſite for the ſucceſs of this operation is, that the ſolution of tin ſhould not be turbid: and as the nitrous acid in diſſolving tin converts a great deal of this metal into a white calx, care muſt be taken, that the proportion of nitrous acid in the aqua regia employed for the ſolution of the two metals be not too great. A too great proportion alſo of marine acid is to be avoided; as this acid, when in too great quantity, blackens the ſurface of the tin, and thereby impedes its ſolution in the aqua regia. He recommends, therefore, to prepare the aqua regia by adding to aqua fortis $\frac{1}{4}$ of its weight of ſpirit of ſalt; and if, upon adding a ſmall piece of tin, a perfect ſolution takes place without expoſure to heat, the acids are in due proportion; but if a black calx remains undiſſolved, he adviſes to add more nitrous acid, and if a whitiſh calx, more marine acid: the ſolution is to be performed ſlowly and without heat, by adding ſmall portions of tin only at a time, till all is diſſolved. He does not find it neceſſary that the ſolutions of gold and tin ſhould be ſaturated, as Baumé aſſerts. He ſays that unleſs the ſolution of tin be recently prepared, it is not fit for the precipitation of the purple precipitate; that by ſtanding a longer or ſhorter time, according to the veſſel being well or ill ſtopped, it loſes its dark colour, and its power of producing the purple precipitate; both which return upon adding a piece of tin. The ſolutions undiluted being mixed, a dark-coloured not a purple precipitate was obtained. Diſtilled water ought to be uſed. Well-water gave a violet colour, owing to the earthy particles in it.

Long cylindrical pieces of glaſs, called Jew's glaſs, are commonly ſold, and much uſed by manufacturers of glaſs-toys. This glaſs, though perfectly colourleſs, yet when it is expoſed to the heat and flame of a lamp, acquires a beautiful ruby colour, exactly ſimilar to that of pure glaſs melted with powder of Caſſius. As no other known ſubſtance but gold gives that colour to glaſs, we may preſume that this glaſs contains ſome of that metal. Its want of colour proceeds from its having been melted in a covered pot; by means of which it is defended from flame or ſmoke, which ſeem to be neceſſary to give to this glaſs its peculiar colour.

Dr. Lewis obſerves, that though a purple or a ruby colour may eaſily, by the methods publiſhed, be applied upon glaſs or enamels, and introduced into the maſs by fuſion, the way of equally diffuſing ſuch a colour through a quantity of fluid glaſs is ſtill a ſecret. That author ſays, that he has made ſeveral trials of this kind, in one of which the glaſs was uniformly tinged of a ruby colour; and in the other various colours, as yellow, red, and brown, appeared, and were unequally diffuſed: but he had not diſcovered the circumſtances upon which theſe differences depend. Orſchal in his Treatiſe, Sol ſine Veſte, gives a proceſs by which he obtained a fine ruby glaſs. He directs, that the powder of Caſſius ſhould be ground with ſix times its quantity of Venice glaſs finely powdered; and that this mixture ſhould be well mingled with a fritt conſiſting of equal parts of borax, nitre, and fixed alkaline ſalt, and four times as much calcined flint as of any of the ſalts: but he does not mention the proportion of the powder of Caſſius to the fritt, nor in what manner the fuſion is to be performed.

Kunkel ſays, that one part of the powder of Caſſius is ſufficient to give a ruby colour to twelve hundred and eighty parts of glaſs.

Dr. Franklin obſerves, that gold-leaf placed betwixt two plates of glaſs being expoſed to an electrical ſhock, ſtained the contiguous glaſs with red ſpots, which were ſunk into the body of the glaſs.

PRINCIPLES. Among the various diviſions or arrangements of chemical principles, that which follows their reſpective degrees of ſimplicity muſt undoubtedly prove the moſt uſeful, becauſe the more compounded bodies will eaſily aſſume a regular order when their reſpective principles are known and properly claſſed. There is however a limit in the advantages, that may be derived even from this method of diviſion. The more we ſucceed in ſimplifying the principles of bodies, the more difficult it is to determine truly what paſſes in chemical operations; becauſe theſe principles, when in their moſt diſtinct ſtate, have the aerial form, and cannot therefore be managed or weighed without conſiderable difficulty From this cauſe it is that, while we have no diſputes concerning the changes of combination in groſſer or leſs ſimple ſubſtances, the moſt eminent chemiſts often differ in their opinions concerning the tranſitions of firſt principles from one combination to another; and are not agreed concerning the exiſtence of ſome of them. The peculiar properties of bodies may be changed, either by the addition or ſubtraction of ſome of their component parts; and it is eaſy to form a notion that ſuch a change may alſo happen by a mere alteration in the diſpoſition or relative arrangement of their parts, without any change in their quantities. To determine which of theſe events takes place, when we behold only the conſequent change, is ſometimes impracticable, for want of a ſufficient number of facts; and in moſt caſes the complete inveſtigation requires the unprejudiced and patient exertion of all the powers of the mind. It appears proper therefore in an elementary arrangement, to fix our attention chiefly on the moſt palpable component parts of bodies, which are ſufficiently ſimple; and where they are not the ſimpleſt to conſider their principles in the analytical method.

The component parts of bodies are either,

1. Principles whoſe exiſtence is doubtful: theſe are heat, light, and phlogiſton.
2. Principles which have not been exhibited in a ſolid or fluid ſtate, or diſſolved in water, in any notable proportion: theſe are vital air, phlogiſticated air, and inflammable air.
3. Water.
4. Earths.
5. Alkalis.
6. Acids.
7. Metals.
8. Mineral combuſtibles. See the articles reſpectively.
9. Parts of organized ſubſtances, whether obtained by mechanical preſſure; by ſimple

ſimple ſolution in water or ardent ſpirit, by a gentle or a ſtrong heat, by the action of ſolvents, or by ſpontaneous decompoſition.

The only general diviſion of bodies at preſent referred to in the writings of modern chemiſts, is that by which they are claſſed into three kingdoms, called the animal, vegetable, and mineral kingdoms. The kind of bodies arranged in the two firſt kingdoms is obvious from the terms; and all other bodies are conſidered as belonging to the mineral kingdom.

Alkalis, acids, and ſuch compounds as they enter into, are diſtinguiſhed generally by the name of ſalts. The leading character of ſalts is a ſtrong tendency to combination, there being no bodies in nature which are not acted upon by ſome ſaline ſubſtance. This tendency appears in their eminent degree of ſolubility in water. All bodies known only by the name of ſalts, are ſoluble in leſs than two hundred times their weight of boiling water. The ſame cauſe produces their ſapidity, or taſte, which was regarded by the earlier chemiſts as a diſtinctive character of ſalts.

Metals are ſometimes claſſed with combuſtible bodies; and, ſtrictly ſpeaking, they are combuſtible. But as none of them poſſeſs this property in ſuch a degree as to burn away in the common air, without the co-operation of other inflammable bodies, which are neceſſary to maintain their high temperature; and as they poſſeſs other remarkable properties peculiar to themſelves—they require to be placed in a ſeparate claſs.

For another more ſtrict general arrangement of the objects of chemiſtry, ſee the Table of Chemical Nomenclature, article Nomenclature, and alſo the Table of the Component Parts of Bodies in the Appendix.

PRINTERS' INK. See Ink.

PRUSSIAN BLUE. See Blue Prussian.

PUDDINGSTONE. Breccias. Stones which conſiſt of a ſiliceous ground or cement (commonly petro-ſilex, jaſper, or ſiliceous grit) in which pebbles of ſilex or agate are interſperſed; if theſe be round or oval, they are called puddinging-ſtones; if angular, breccias. Of the coarſer ſorts mill-ſtones are often made.

PUFF BALL. See Lycopodium.

PULVERIZE. See Powder.

PUMICE-STONE. Pierre Ponce, Bimſtein. This ſeems rather a volcanic ejection than a volcanic product; its colour is gray, white, reddiſh-brown, or black; it is hard, rough and porous, and conſiſts of ſlender fibres parallel to each other; very light, for it ſwims on water, and difficultly gives fire with ſteel. It is thought to have originally been an aſbeſtos decompoſed by the action of fire.

One hundred parts of it contain, according to Bergman, from ſix to fifteen of magneſia, with a very ſmall proportion of calcareous earth; the remainder ſilex.

PURBECK STONE. A hard ſand ſtone, the cement of which is calcareous.

PURIFICATION. By purification is meant any chemical operation by which ſubſtances required to be obtained pure and ſingle, are ſeparated from other heterogeneous matters with which they happen to be mixed.

As the ſeveral chemical agents and other matters are generally more or leſs confounded, and even combined with ſubſtances of different natures, and as we require in many accurate experiments that they ſhould be very pure, we muſt, therefore, apply the proper methods to give them the neceſſary degree of purity.

But theſe methods differ very much according to the nature of the ſubſtance to be purified. They muſt be appropriated to their peculiar natures, and alſo to the nature of the ſubſtances to be ſeparated. For the ſeveral purifications, we are obliged to employ almoſt all the operations of chemiſtry. Hence many operations are only true purifications, although they are not ſo called. For inſtance, all the ſecond diſtillations and ſublimations called rectifications, are nothing elſe than purifications. They are employed for the purification of volatile ſubſtances from others that are fixed, or leſs volatile. In this claſs may be ranged the rectifications of oils of volatile ſpirits and ſalts, of ardent ſpirits, and even of mineral acids; and the ſublimations of ſulphur, of arſenic, of cinnabar, of ſalt of amber, of flowers of benjamin, and of ſal ammoniac. See RECTIFICATION and SUBLIMATION. Alſo the repeated ſolutions, filtrations, evaporations, and cryſtallizations of neutral ſalts are only means of purifying them. See CRYSTALLIZATION. Several calcinations, and particularly thoſe of fixed alkalis, are intended merely to purify them, by depriving them of a greaſy matter or ſuperabundant inflammable principle. See POTASH. Many ſolutions and precipitations by the humid way, particularly in the operations of parting, and of luna cornea, are performed for the purification of the perfect metals from their allay. Laſtly, the repeated fuſions of metallic ſubſtances, the ſmelting of ores, cupellations and refining, are true purifications of metallic matters. Amongſt all theſe operations but a very few are called purifications: ſuch as the purification of ſilver by nitre, of gold by antimony; of both which we ſhall now treat.

PURIFICATION OF SILVER BY NITRE. The ſilver to be purified by nitre is to be firſt granulated, and then mixed with a fourth part of its weight of dry nitre, an eighth part of pot-aſh, and a little common glaſs, all in powder. This mixture is to be put into a good crucible, two-thirds of which only muſt be full. This crucible is to be covered with a ſmaller crucible inverted, and luted to the former, and in the bottom of which a ſmall hole has been made. The crucibles thus diſpoſed are to be placed in a furnace, capable of drawing air ſufficiently to make the fire intenſe enough only to melt the ſilver. Then charcoal is to be put into the furnace to ſuch a height, that only the top of the inverted crucible ſhall be uncovered. The coal is then to be kindled, and the veſſels to be made moderately red: a hot coal ought to be put upon the ſmall hole in the bottom of the inverted crucible. If a ſhining light be obſerved round this coal, and a ſlight hiſſing noiſe be at the ſame time heard, we may know that the operation proceeds well. The fire muſt be ſuſtained at the ſame degree till theſe appearances ceaſe; when it muſt be increaſed ſo that the ſilver be well melted, and then the crucibles are to be taken out of the furnace. The larger crucible is to be broken when it is cold, and the ſilver will be found at the bottom covered with a green alkaline ſcoria. If the metal be not ſufficiently pure and ductile, the operation muſt be again repeated.

This operation is founded on a property which nitre has of effectually calcining all imperfect metals; and alſo upon a property of calcined metals by which they cannot be united with others in their metallic ſtate. This being eſtabliſhed, when ſilver allayed with copper or other imperfect metals is to be treated with nitre, this ſalt quickly calcines theſe imperfect metals by detonating with them; and they are no ſooner calcined, than they are rendered incapable of remaining united with the ſilver. Theſe metallic calxes being alſo ſpecifically lighter, riſe above the ſilver, where they meet the alkaliſed nitre and pot-aſh, with both which they form a ſcoria. The ſilver being capable of reſiſting the action of the nitre, is thus diſengaged from its allay, is fuſed, and collected at the bottom of the crucible.

As the purification of ſilver is effected by the detonation of nitre with the imperfect metals, and as this detonation is always accompanied with ſwelling and effervescence, the crucibles muſt not be too firmly cloſed, otherwiſe the effervescence might break them, and ſome of the contained matter might be loſt: therefore a ſmall hole is left in the upper crucible, which ſerves as a cover to the other; beſides, the empty ſpace left in the veſſels thus diſpoſed, allows the matter contained to ſwell a little without loſs.

This ſmall hole is alſo very uſeful to ſhew the proper degree of fire, during the operation, as has been ſaid. The light and the hiſſing noiſe which may be perceived when a coal is applied, are occaſioned by vital air extricated from the nitre, by the decompoſition of part of its acid at that violent heat. When theſe effects are too conſiderable, and that a ſenſible hiſſing may be heard at the ſmall hole, even when a hot coal is not applied to it, we may know that the detonation is too violent. In that caſe the fire muſt be leſſened, otherwiſe much of the nitre would ſublime or be driven off, and together with it ſome part of the ſilver would be waſted. And even notwithſtanding all the precautions that can be uſed, this operation can ſcarcely be performed without ſome loſs of the ſilver. Small grains of ſilver are always to be ſeen in the upper crucible, and about the ſmall hole in it. This inconvenience prevents the operation from being employed to determine the value of the ſilver, for which purpoſe cupellation is therefore uſed. See SILVER, NITRE, and DETONATION OF NITRE.

PURIFICATION OF GOLD BY ANTIMONY. To purify gold from its allays, by antimony, the gold is to be melted in a crucible large enough to contain thrice the quantity of metal. When the gold is melted, twice its weight of crude antimony powdered is to be thrown upon it; the crucible is to be covered, and the matter left ſome minutes in fuſion: after which, when the mixture is well fuſed, and ſo hot that its ſurface ſparkles, it is quickly to be poured into an iron cone previouſly heated and greaſed. By ſtriking the cone againſt the ground, the deſcent of the regulus will be aſſiſted; and when the cone is cold, it is to be inverted, and the matter taken out. This matter conſiſts of two ſubſtances; the upper one of which is compoſed of the ſulphur of the antimony united with the metals with which the gold was allayed, and the lower is the gold united with a quantity of the regulus of antimony proportionable to the quantity of metals which have been ſeparated from the gold, and which are now united with the ſulphur of the antimony. This regulus of gold may be ſeparated from the ſulphurated metals which cover it, and will be found to be ſo much leſs yellow, that is, mixed with ſo much more regulus of antimony, as the gold was more allayed.

As a ſingle fuſion is not generally ſufficient to diſengage the gold from all its allay, it ought to be fuſed again in the ſame manner, and with the ſame quantity of antimony, and even a third time, if the gold was much allayed. It is fuſible with leſs fire the ſecond and third time than the firſt, from the regulus of antimony which is united with it.

This firſt part of the purification of gold by antimony is founded on a property of ſulphur, by which it is incapable of uniting with gold, and is ſtrongly diſpoſed to unite with all other metallic ſubſtances, excepting platina and zinc;

and

and alſo upon this property of ſulphur, that it has leſs affinity with regulus of antimony than with any metallic ſubſtance with which it can unite. Hence, when gold allayed with ſilver, copper, iron, lead, &c. is fuſed together with crude antimony, theſe latter metals unite with the ſulphur of the antimony, while the reguline part, diſengaged by them from its ſulphur, unites with the gold. The ſeparation of metals from gold is then really occaſioned by the ſulphur of the antimony. This purification of gold is conſequently a kind of dry parting, but it ſucceeds better than the dry parting by ſulphur alone. The reaſon of this difference is, that ſulphur being very volatile and inflammable is in great meaſure diſſipated and conſumed, when it is employed alone, before it can ſeize the metals allayed with the gold; whereas, when it is already united with a metallic ſubſtance, as it is in the antimony with the reguline part, which prevents it from being quickly conſumed and diſſipated, it may be much more eaſily applied to the metallic ſubſtances allayed with gold. Notwithſtanding this advantage, as a quantity of regulus of antimony is always united with the gold, proportionable to the quantity of metallic ſubſtances ſeparated by means of the ſulphur of the antimony; and as the ſeparation of this regulus from the gold requires much time; therefore, when we would purify gold that is much allayed, ſuppoſe under ſixteen carats, we ought to add along with the antimony ſome pure ſulphur, that we may have a leſs quantity of regulus to ſeparate afterwards from the gold.

When theſe firſt fuſions have been well made, the gold obtained is allayed with only regulus of antimony. But as this ſemi-metal is very volatile and very combuſtible, it may be ſeparated from the gold by a ſufficiently long expoſure to the action of fire. For this purpoſe the regulus of gold obtained by the former operation is to be put into a large crucible, and heated ſufficiently to keep it in good fuſion. With this heat, the antimony will be diſſipated into ſmoke. If the heat be too ſtrong, ſome of the gold will be carried off with the antimony. The operation therefore muſt be performed ſlowly; and it continues a long time when much of the regulus of antimony is united with the gold; but it may be abridged by blowing on the ſurface of the metallic maſs, which greatly aſſiſts in the calcination and evaporation of all bodies, and particularly that of the regulus of antimony. When a part of the regulus is diſſipated, more heat is required to keep the metal fuſed, and therefore the fire muſt be increaſed towards the end of the operation: beſides, when only a ſmall quantity of regulus of antimony remains, it is ſo covered by the gold, and protected from the action of the fire and air, that a ſtronger heat is neceſſary to evaporate it. The ſmoke ceaſes entirely towards the end of the operation, although ſome regulus ſtill remains united with the gold. The purification is completed by means of a little nitre thrown into the crucible, which effectually calcines the remaining regulus of antimony. Sometimes, after theſe operations, the gold is found to be deprived of much of its uſual ductility, which however is eaſily reſtored to it by fuſing it with nitre and borax.

The ancient chemiſts called antimony the balneum regis, or the balneum ſolis, and the lupus metallorum, from this property which it poſſeſſes of purifying gold. The ſulphur of this mineral does, indeed, ſeize almoſt all the metals with which gold can be allayed; but theſe metals are not deſtroyed, but only reduced to a ſort of mineral ſtate by the ſulphur, forming the ſcoria, from which they may be obtained. Therefore, when the gold contained much allay of ſilver, the ſcoria is very valuable, ſince it contains all the ſilver which was united with the gold.

This ſcoria ought to be preſerved and treated like an ore of ſilver, and thus the metal extracted from it. See PARTING.

PURPLE DYE. By the mixture of red and blue, we obtain violet, purple, dove colour, panſey, amaranth, lilac, mauve, and a great number of other ſhades, determined by the nature of the ſubſtances the red colour of which is combined with the blue, by the proportion of theſe ſubſtances, and the different ſteps of the proceſs.

According to Hellot's obſervations, ſtuff which has been dyed ſcarlet, takes an unequal colour when blue is to be united with it. The blue is therefore given firſt, which even for violet and purple ought not to be deeper than the ſhade diſtinguiſhed by the name of ſky-blue: a boiling is given with alum mixed with two-fifths of tartar, the ſtuff is then dipped in a bath compoſed of nearly two thirds as much cochineal as for ſcarlet, to which tartar is always added. The circumſtance which diſtinguiſhes the proceſs for purple from that for violet, is, that for the former, a lighter blue ground is given, and a larger proportion of cochineal is employed. Theſe colours are frequently dyed after the reddening for ſcarlet, ſuch quantities of cochineal and tartar being added as are thought neceſſary. The operation is conducted in the ſame manner as for ſcarlet.

Lilacs, pigeons-necks, mauves, &c. are commonly dipped in the boiling which has ſerved for violet, after alum and tartar have been added to it; the blue ground having been proportioned to the ſhade required: the quantity of cochineal is alſo adjuſted in a ſimilar manner: a little ſolution of tin is added for ſome reddiſh ſhades, ſuch as peach bloſſom. It muſt be obſerved, that though the quantity of cochineal is diminiſhed according to the lightneſs of the ſhade required, the quantity of tartar is not leſſened, ſo that the proportion of it compared with that of the cochineal is ſo much the greater, as the colour required is lighter.

Mr. Poerner is of opinion, that to obtain the colours compoſed of red and blue, it is advantageous to employ the ſolution of indigo in ſulphuric acid, becauſe a greater variety of ſhades is thus more eaſily procured, and the proceſs is ſhorter and leſs expenſive. The colours obtained in this way are indeed much leſs durable than when the blue vat is employed; but Mr. Poerner aſſerts, that they poſſeſs durability, when ſolution of indigo to which alkali has been added is employed.

He prepares a pound of cloth with three ounces of alum, by boiling it for an hour and an half, and leaving it a night in the liquor after it is cold. He makes the bath with an ounce and an half of cochineal, and two ounces of tartar, boiling it for three-quarters of an hour; and then adding two ounces and a half of ſolution of indigo, he ſtirs it, and makes it boil gently for a quarter of an hour: he thus obtains a very beautiful violet.

For the different ſhades which reſult from the mixture of red and blue, according as one or other of the colours prevails, he increaſes or diminiſhes the proportion of the ſolution of indigo; he increaſes it as far as five ounces, and diminiſhes it to five drams for each pound of cloth: he alſo reduces the quantity of cochineal, but never below an ounce, becauſe the colour would become too dull: he changes the proportion of tartar, and finally, he varies the preparation given to the cloth, by the addition of tartar or ſolution of tin in different quantities.

In ſilk, two kinds of violets are diſtinguiſhed, the fine, and the falſe: the laſt is made either with archil, or brazil-wood.

For fine violet the ſtuff is firſt paſſed through cochineal, and afterwards dipped in the vat; the ſilk is prepared and dyed in the cochineal in the ſame manner as for crimſon, except that neither tartar nor ſolution of tin, which ſerve to heighten the colour, are employed. More or leſs cochineal is uſed, according to the intenſity of the ſhade required. The common proportion for a fine violet, is two ounces for each pound of ſilk. When the ſilk is dyed, it is waſhed at the river and beetled twice, then dipped in a vat of greater or leſs ſtrength, according to the depth we wiſh to give the violet; laſtly, it is waſhed and dried with the precautions which are proper for all colours dyed in the vat. To give greater ſtrength and beauty to the violet, it is commonly paſſed through the archil bath; and this cuſtom, which is frequently abuſed, is indiſpenſable for the light ſhades, the colour of which would otherwiſe be too dull.

When the ſilk has been dyed with cochineal as above directed, a very light blue ſhade muſt be given to it for purple; only the deepeſt ſhades are dipped in a weak vat; ſuch as are leſs deep are only dipped in cold water, into which a little of the liquor of the vat has been put, becauſe they would take too much blue in the vat itſelf, though ever ſo weak. The light ſhades of this colour, ſuch as gilly-flower, gridelin, and peach-bloſſom, are made in this way, by diminiſhing the proportion of cochineal.

The falſe violets in ſilk are produced in many different ways; thoſe which are moſt beautiful, and moſt in uſe, are prepared with archil. The ſtrength of the archil bath is adapted to the colour we wiſh to obtain; the ſilk is turned in it on the ſkein-ſticks, after having been beetled at the river after ſcouring: when the colour is thought to be ſufficiently deep, a pattern is tried in the vat, to ſee whether it takes the violet we wiſh for. If the ſhade is found to be of the proper depth, the ſilk is beetled at the river and dipped in the vat as for the fine violets; leſs of the blue, or leſs of the archil colour are given, according as we mean that the violet ſhould incline to red or blue.

According to Mr. Guhliche, beautiful violets may be produced in ſilk by means of the ſolution of indigo; but they poſſeſs little durability, and become reddiſh, becauſe the colour of the indigo fades firſt.

A pound of ſilk is ſoaked in a bath compoſed of two ounces of alum and two ounces of ſolution of tin, after being decanted from the ſediment formed in the mixture. The dye bath is prepared with two ounces of cochineal (reduced to powder with a dram of tartar) and the remainder of the bath which has ſerved as mordant, with the addition of a ſufficient quantity of water; after a ſlight boiling, ſuch a quantity of ſolution of indigo is added, as gives the bath a proper ſhade of violet; the ſilk is then immerſed, and boiled until it has acquired the proper ſhade, when it is wrung, waſhed in a ſtream, and dried in the ſhade, like all delicate colours. The bath is exhauſted by the light ſhades.

A violet is given to ſilk, by dipping it in water with which verdegris has been mixed, inſtead of aluming it, and then giving it a bath of logwood, when it aſſumes a blue colour, which is changed to violet, either by adding alum to the bath, or by dipping it in a weaker or ſtronger ſolution of alum, which gives the particles of logwood a red colour. It is unneceſſary to obſerve, that this violet is of a very fading nature, and only a moderate degree of beauty. One poſſeſſing much greater beauty, and to which a conſiderable degree of intenſity may be added, is made by dipping the alumed ſilk in a bath of brazil-wood, and again, after it has been waſhed at the river, in a bath of archil. Madder is alſo employed in dyeing cloth, after it has had a blue ground; couleur de roi, minime, and obſcure amaranth, are thus obtained; galls are commonly added to the madder, and for the light ſhades, brazil-wood; for the deep ſhades, more or leſs browning is given, with a ſolution of vitriol of iron. Theſe colours are rendered more beautiful by the addition of kermes, or more eſpecially of cochineal.

By employing ſolution of indigo with madder, in the ſame way as with cochineal, we may, according to Mr. Poerner, obtain brown colours inclining the more to red, the leſs ſolution of indigo we employ; alum and tartar may ſerve for the preparation, but alum muſt not be put into the bath.

Mr. Poerner employs brazil-wood and ſolution of indigo, to obtain different colours, which incline more or leſs to blue and red, by a proceſs ſimilar to that pointed out for cochineal and madder. Theſe are beautiful, but durability cannot be expected in colours obtained by ſuch means. The ſubſtances which render them moſt fixed, are vitriolated lime, vitriol of zinc, or white vitriol, and acetite of copper, or cryſtallized verdegris, which muſt be added to the bath.

Logwood is alſo employed to make ſloe, damaſcene, purple and other ſhades. This wood, with the addition of galls, very eaſily communicates all theſe colours to wool previouſly dyed blue. When we wiſh to brown them, a little vitriol of iron is employed, and by this means we produce ſhades, which are much more difficultly obtained from durable ingredients, but they poſſeſs little ſtability: durable colours which have been highly eſteemed, have however been obtained from brazil and logwood. Berthollet, from whoſe art of dying the preſent article is extracted, was indebted to Mr. Decroizille, for the following particulars of the proceſs employed, which he gives in the words of the author.

M. Giros de Gentilly is the firſt who ſucceeded in France, in obtaining a durable dye from violet-wood fixed by ſolution of tin. His firſt eſſays were made at Louviers, with Meſſrs. Petou, nephew, and Frigard, about twelve years ago. From what he had ſuffered to tranſpire reſpecting the ſubſtances which compoſed his mordant, I ſucceeded in imitating him tolerably well. I made a ſolution of tin in ſulphuric acid, to which I then added muriat of ſoda, red acidulous tartrite of potaſh, and ſulphat of copper. My ſucceſs was ſo great as to induce M. Giros to offer me a partnerſhip in the very lucrative trade in this article, which he carried on at Louviers, Elboeuf, Abbeville, Sedan, and the Pays de Liege. M. Giros then taught me a much more convenient mode of forming this compound; it conſiſts in making a ſolution of tin in a mixture of ſulphuric acid, muriat of ſoda, and water; to this ſolution, the tartrite and ſulphat are added, in the form of powder. Of this mordant we made no leſs than fifteen hundred quarts in twenty-four hours, in a ſingle leaden veſſel moderately heated. We carried on a very profitable trade in this article at the rate of thirty ſols (fifteen pence Engliſh) per pound for three years, ſince which time it conſtantly declined, until we loſt it altogether; the reaſon of which was this: M. Giros having ſuffered his ſecret to tranſpire, we had a number of imitators, who at firſt ſucceeded in a leſs degree, but afterwards better than ourſelves. In a compound conſiſting of ſo many ingredients as this, in an operation which is ſtill ſo obſcure as that whereby colours are fixed, it is almoſt impoſſible to arrive at perfection by any other means than random trials, which may be infinitely varied by the different proportions, and more eſpecially by the modus agendi, and to a much greater extent, than chemiſts who had beſtowed leſs time on this ſubject than I have done, would ſuppoſe. I am therefore not aſhamed to confeſs, that I was forced to abandon the buſineſs, while I ſaw, and ſtill ſee, thoſe who are no chemiſts deriving a very comfortable profit from it. What determined me to abandon it altogether, was the invention of the new proceſs for bleaching linen, to the improvement of which I have almoſt entirely devoted myſelf.

Having given you the hiſtory of the mordant for the prune de Monſieur, I ſhall mention the mode of employing it, and its effects.

If it is wool in the fleece which is to be dyed, one-third of its weight of mordant is required; if it is a ſtuff, only one-fifth is neceſſary. A bath is prepared of a degree of heat which the hand can bear, with which the mordant is well mixed, and the wool or ſtuff dipped in it and properly ſtirred, the ſame degree of heat being kept up for two hours, and even increaſed a little at laſt; it is then taken out, aired, and very well waſhed: a freſh bath of pure water at the ſame heat is prepared, a ſufficient quantity of the decoction of violet wood is added; the ſtuff immerſed, ſtirred, and the fire increaſed to a boiling heat, which is continued for a quarter of an hour: the ſtuff being then taken out, aired, and carefully rinſed, the dyeing is finiſhed. If the decoction of one pound of violet wood of Campeachy has been employed for three pounds of wool, and a proportionate quantity for ſtuffs, which require leſs, a fine violet is produced, to which a ſufficient quantity of brazil-wood gives the ſhade commonly known by the name of prune de Monſieur.

The colouring ſubſtances which are capable of being advantageouſly fixed on wool by this mordant, are thoſe of violet and red logwood (logwood and brazil), and fuſtic (bois de fuſtet). Bois jaune (morus tinctoria) alſo affords tolerable colours. The colour which is thus given by violet and red wood is liable to be changed in the fulling, by means of the ſoap or the urine employed; and this change, which is always produced by alkaline ſubſtances, is remedied by a bath very ſlightly acid, and a little hot, called brightening, for which the ſulphuric acid is preferred. The colour comes out as deep and oftener brighter than before the change. Wools dyed by means of this mordant, admit of being ſpun into a more beautiful and finer thread than when alum has been employed. By leaving out the ſulphat of copper, more beautiful colours are obtained from fuſtic and yellow wood, as well as from weld. Madder gives an orange-red colour, but leſs deep than with an equal quantity of alum; the omiſſion of the ſulphat of copper renders the wool much more harſh, and beſides, the mordant thus prepared gives but indifferent colours with violet, and more eſpecially with red wood. One of the great defects of this mordant before it was improved, was, and frequently ſtill is, to render the colours uneven; whenever they are uniform, they turn out always very beautiful, harmleſs, and ſoft. This proceſs ſucceeds equally well on ſilk. By ſubſtituting acetite of lead for ſulphat of copper, it ſucceeds tolerably well in cotton and thread previouſly galled. The employment and conveyance of this mordant are inconvenient, on account of the heavy ſediment which half fills the veſſel, under a corroſive liquor which can only be kept in ſtone-ware. I have, however, found a remedy for theſe inconveniences, by omitting the water in the receipt, by which means I have only a kind of paſte, the uſe of which is more convenient, and the carriage two-fifths cheaper. Now that common ſalt is cheap (in France), I may poſſibly return to the employment of furniſhing our dyers with this mordant, of a better quality, in my opinion, than that with which they are ſupplied, and more eſpecially at a much cheaper rate; but I muſt firſt devote ſome more time to the compoſition and employment of your lixivium.

Here ends the account of Mr. Decroizille.

The moſt common method of dyeing thread and cotton, violet, is firſt to give them a blue ground in the vat, proportionate to the ſhade we want, and to dry them; they are then galled, in the proportion of three ounces of galls to a pound: they are left for twelve or fifteen hours in this gall bath, after which they are wrung and dried again. The thread and cotton are then paſſed through a decoction of logwood, and when well ſoaked are taken out, and two drams of alum, and one dram of diſſolved verdegris for each pound of thread and cotton, are added to the bath; the ſkeins are then re-dipped on the ſkein-ſticks, and turned for a full quarter of an hour, when they are taken out to be aired; after which they are again completely immerſed in the bath for a quarter of an hour, then taken out and wrung. Laſtly, the vat which has been employed is emptied; half of the decoction of logwood which had been reſerved is poured in, two drams of alum are added, and the thread dipped afreſh, until it is brought to the ſhade required. The decoction of logwood ought to be ſtronger or weaker according to the ſhade we want: this violet ſtands the action of the air tolerably well, but cannot be compared in durability to that obtained by means of madder, for which ſee that article.

In the production of violet by cochineal, it may be obſerved, that the woollen ſtuff has been diſpoſed to take a crimſon, by the bath, which contains alum; but the tartar added to the dye bath brings the colour back to red; this is a general property of all acids.

For purple, the red is rendered a little more predominant, by increaſing the quantity of the cochineal, and diminiſhing the intenſity of the blue ground.

The ſhades bordering on theſe two colours ſhould have a more diſtinct red, and the ſame proportion of tartar is preſerved, though that of cochineal and the depth of the blue ground are diminiſhed.

For ſilk, the tartar is omitted: it naturally acquires from cochineal a colour, to which it is only neceſſary to add a ſlight blue ſhade to produce purple; a deeper blue ſhade gives a violet colour; but to increaſe the fulneſs of the violet and give it brightneſs, archil muſt be employed.

When the ſolution of indigo in ſulphuric acid is uſed, the ſulphuric acid acts in different ways on the red ſubſtance employed; it produces little change in the colour of cochineal, already diſpoſed to a crimſon tinge by the aluming; but it ſhould give a fawn colour to madder, upon which acids readily produce this effect; and it does not ſeem probable, that that ſubſtance could be employed with advantage in this proceſs; it is better to employ it in dyeing ſtuff which has already received a blue ground. Brazil and logwood too ſeem ill adapted to produce fine colours with the ſulphuric ſolution of indigo, becauſe acids alſo change them yellow, though in a leſs diſtinct degree; but they retain their red colour, as already obſerved, when their colouring particles are precipitated by calx of tin.

Berthollet offers the following explanation of the proceſs of M. Decroizille, after expreſſing his diffidence to hazard an opinion unſupported by direct experiment, on ſo complicated a proceſs.

The ſea ſalt is decompoſed by the ſulphuric acid, and the muriatic acid thus ſet at liberty diſſolves the tin; a part of the tin is precipitated by the acid of tartar, producing the ſediment which has been noticed. The calx of copper forms the blue with the colouring particles of the logwood; the calx of tin produces violet with the ſame wood, and red with the colouring particles of the brazil-wood.

As the liquor retains an exceſs of acid, it might perhaps be uſeful to ſubſtitute cryſtals of verdegris to the vitriol of copper, becauſe then the free acid would have leſs activity; perhaps it might be ſtill better to employ mere verdegris, becauſe that part of the calx of copper which is uncombined in it, would unite with the exceſs of acid, by which means leſs acid would remain in the liquor; perhaps the quantity of tartar ſhould be diminiſhed, becauſe leſs of the tin would then be precipitated.

PUTREFACTION. Every living body, when once deprived of life, performs a retrograde proceſs, and becomes decompoſed. This decompoſition is called fermentation in vegetables, and putrefaction in animal ſubſtances. The ſame cauſes, the ſame agents, and the ſame circumſtances, determine and favour the decompoſition of vegetables and animals, and the difference of the productions which are obtained ariſes from the difference of the conſtituent parts of each *.

Air is the principal agent of animal decompoſition, but water and heat prodigiouſly facilitate its action. “ Fermentatio ergo definitur quod ſit corporis denſioris rarefactio, particularumque aërearum interpoſitio: ex quo concluditur debere in aëre fieri nec nimium frigido, ne rarefactio impediatur; nec nimium calido, ne partes raribiles expellantur.” Becher, Phyſ. Sub. lib. i. ſ. 5. p. 313. edit. Francofurti.

An animal ſubſtance may be preſerved from putrefaction by depriving it of the contact of the air; and this proceſs may be accelerated or retarded by varying or modifying the purity of the ſame fluid.

In thoſe circumſtances wherein we ſee putrefaction developed without the contact of atmoſpherical air, the effect is produced by the water which impregnates the animal ſubſtance, becomes decompoſed, and affords the element and the agent of putrefaction. Hence no doubt it ariſes that putrefaction is obſerved in fleſh cloſed in a vacuum. See Lyons, Tentamen de Putrefactione.

Moiſture is likewiſe an indiſpenſable requiſite to facilitate putrefaction; and any ſubſtance may be defended from this change by completely drying it. This was performed by Villaris and Cazalet of Bourdeaux, by means of ſtoves. The meat thus prepared was preſerved for ſeveral years without having contracted any bad flavour. The ſands and light porous earths preſerve the bodies of men only by virtue of the property of exhauſting their juices, and drying the ſolids. From this cauſe it is that entire caravans have been diſcovered in Arabia, conſiſting of men and camels perfectly preſerved in the ſands under which the impetuous winds have buried them. In the library of Trinity College Cambridge, in England, a human body may be ſeen perfectly preſerved, which was found under the ſand in the iſland of Teneriffe. Too much humidity impedes putrefaction, according to the obſervation of the celebrated Becher: “ Nimia quoque humiditas a putrefactione impedit, prout nimius calor; nam corpora in aqua potius gradatim conſumi quam putreſcere, ſi nova ſemper affluens ſit, experientia docet: unde longo tempore integra interdum ſubmerſa prorſus a putrefactione immunia vidimus; adeo ut nobis aliquando ſpeculatio occurreret, tractando tali modo cadavera anatomiæ ſubjicienda, quo diutius a fœtore et putrefactione immunia forent.” Phyſ. Sub. lib. i. ſ. 5. cap. 1. p. 277.

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* The general part of this article is from Chaptal.

In order, therefore, that a body may putrefy, it is neceſſary that it ſhould be impregnated with water, but not that it ſhould be inundated. It is likewiſe neceſſary that this water ſhould remain in the texture of the animal body, without being renewed. This condition is requiſite, 1ſt, To diſſolve the lymph, and to preſent to the air the moſt putreſcible ſubſtance with the greateſt extent of ſurface. 2d, In order that the water may itſelf become decompoſed, and by this means afford the putrefactive principle. Putrefaction is retarded and ſuſpended by baking, becauſe the fleſh is dried, and by that means deprived of the humidity, which is one of the moſt active principles of its decompoſition.

A moderate degree of heat is likewiſe a condition favourable to the animal decompoſition. By this heat the affinity of aggregation between the parts is weakened, and conſequently they aſſume a ſtronger tendency to new combinations. Hence it ariſes that fleſh meat keeps longer during the winter than the ſummer, and better in cold than in hot countries. Becher has given a very intelligent ſketch of the influence of temperature on animal putrefaction: "Aër calidus et humidus maximè ad putrefactionem facit . . . . . . corpora frigida et ſicca difficulter, imo aliqua prorſus non putreſcunt; quæ ab imperitis proinde pro ſanctis habita fuere. Ita aër frigidus et ſiccus, imprimis calidus et ſiccus, a putrefactione quoque præſervat; quod in Hiſpania videmus, et locis aliis calidis, ſicco-calido aëre præditis, ubi corpora non putreſcunt et reſolvantur; nam cadavera in oriente in arena, imo apud nos arte in furnis, ſiccari et ſic ad finem mundi uſque a putredine præſervari, certum eſt: intenſum quoque frigus a putredine præſervare; unde corpora Stockholmiæ tota hyeme in patibulo ſuſpenſa ſine putredine animadvertimus." Phyſ. Sub. l. i. cap. 1.

Such are the cauſes which are capable of determining and favouring putrefaction; and hence we may perceive the beſt means of preventing, increaſing, or modifying it at pleaſure. A body will be preſerved from putrefaction by depriving it of the contact of atmoſpherical air: for this purpoſe nothing more is required than to place the body in a vacuum, or to envelop it in a covering which may defend it from the immediate action of the air; or elſe to envelop it in an atmoſphere of ſome gaſeous ſubſtance which does not contain vital air. We ſhall obſerve, on this ſubject, that the effects obſerved in fleſh expoſed in the fixed air, nitrous air, &c. are referable to a ſimilar cauſe; and it appears to Chaptal, that it is without ſufficient proof that a concluſion has been drawn that theſe ſame gaſes, internally taken, ought to be conſidered as antiſeptic; becauſe, in the caſes we have mentioned, they act only by defending the bodies they ſurround from the contact of vital air, which is the principle of putrefaction. Putrefaction may be favoured by keeping bodies at a ſuitable temperature. A degree of heat from ſixty-five to ninety degrees diminiſhes the adheſion of the parts, and favours the action of the air: but if the heat be greater it volatilizes the aqueous principle, dries the ſolids, and retards the putrefaction. It is neceſſary therefore, for the decompoſition of an animal—1ſt, That it have the contact of atmoſpheric air; and the purer this air is, the more ſpeedy will be the putrefaction. 2. That it be expoſed to a moderate degree of heat. 3. That its texture be impregnated with humidity.—The experiments of Pringle, Macbride, and Gardane have likewiſe ſhewn us, that putrefaction may be haſtened by ſprinkling the animal ſubſtances with water containing a ſmall quantity of ſalt; and it is to a like cauſe that we ought to refer ſeveral proceſſes uſed in kitchens to produce this effect in food, as well as in the preparation of cheeſe, the curing of tobacco, the making of bread, &c.

Becher expreſſes himſelf as follows on the cauſes which produce putrefaction in living bodies:—" Cauſa putrefactionis primaria defectus ſpiritus vitalis balſamini eſt; ſecundaria, deinde, aër externus et ambicus, qui interdum adeo putrefaciens et humidus-calidus eſt, ut ſuperſtitem in vivis etiam corporibus balſaminum ſpiritum vincat, niſi confortando augeatur; ex quo colligi poteſt, preſervantia a putredine ſubtilia ignea oleoſa eſſe debere."—This celebrated chemiſt concludes, from the ſame principles, that ligatures, copious bleedings, or any debilitation whatever, determines putrefaction. He likewiſe thinks that aſtringents oppoſe putrefaction only by condenſing the texture of the animal parts; for he conſiders rarefaction or relaxation as the firſt effect of putrefaction. He thinks that ſpirituous liquors act as anti-putreſcent merely by animating and ſtimulating the vis vitæ. He affirms that the uſe of ſalted meats, which heat much, aſſiſted by the moiſture very common in ſhips and ſea-ports, produces the ſcurvy; and he obſerves, with reaſon, that the tendency and effect of putrefaction are diametrically oppoſite to thoſe of generation: " nam ſicut in generatione partes coagulantur et in corpus formantur, ita in putrefactione partes reſolvuntur et quaſi informes fiunt."

As the phænomena of putrefaction vary according to the nature of the ſubſtances themſelves, and the circumſtances which accompany this operation, it follows, that it muſt be very difficult to deſcribe all the phænomena which it exhibits. We ſhall therefore endeavour to trace only thoſe which appear to be moſt conſtant.

Every animal ſubſtance expoſed to the air at a temperature above ten degrees of Reaumur, and moiſtened with its own ſerous humour, putrefies; and the progreſs of this alteration appears in the following order:

The colour firſt becomes pale; its conſiſtence diminiſhes; its texture becomes relaxed; the peculiar ſmell of freſh meat diſappears, and is ſucceeded by a faint and diſagreeable ſmell. The colour itſelf at this time inclines to blue; as we ſee in game which begins to turn, in wounds which fall into ſuppuration, in the various parts threatened with gangrene, and even in that putrefaction of the curd which forms cheeſe. Moſt of our food ſuffers the firſt degree of putrefaction before we uſe it.

After this firſt period the animal parts become more and more ſoftened, the ſmell becomes fetid, and the colour of an obſcure brown; the fibrous part eaſily breaks; the texture becomes dry, if the putrefaction be carried on in the open air; but the ſurface becomes covered with ſmall drops of fluid, if the decompoſition be made in veſſels which oppoſe its evaporation.

To this period ſucceeds that which moſt minutely characterizes animal putrefaction. The putrid and nauſeous ſmell which was manifeſted in the ſecond degree, becomes mixed with a ſmell of a more penetrating kind, ariſing from the diſengagement of ammoniacal gas: the maſs becomes ſtill leſs and leſs conſiſtent.

The laſt degree of decompoſition has its peculiar characters. The ſmell becomes faint, nauſeous, and exceedingly active. This, more eſpecially, is contagious, and tranſmits the ſeeds of infection to a great diſtance: it is a true ferment, which depoſits itſelf upon certain bodies, to appear again at long intervals. Van Swieten reports, that the plague having appeared at Vienna in 1677, and having again appeared in 1713, the houſes which had been infected at its firſt appearance were likewiſe infected at the ſecond. Van Helmont aſſerts that a woman contracted an anthrax at the extremity of her fingers, in conſequence of having touched papers impregnated with peſtilential virus. Alexander Benedictus has written, that pillows reproduced the contagion ſeven years after having been infected; that cords had remained infected for thirty years, and likewiſe communicated it, according to Fauſtus. The plague at Meſſina was for a long time concentrated in the warehouſes where merchandize was incloſed with the ſuſpected bales. Mead has tranſmitted the moſt alarming facts concerning the durable impreſſion of contagion.

When the putrefying ſubſtance is in its laſt ſtage, the fibrous texture is ſcarcely diſcernible, and has no longer any appearance but that of a ſoft, diſorganized and putrid maſs. Bubbles are ſeen to eſcape from the ſurface of this matter; and the whole ends by its drying, and becoming reduced to an earthy matter, which is friable when taken between the fingers.

We do not ſpeak of the production of worms; becauſe it appears to be proved that they owe their origin only to the flies which endeavour to depoſit their eggs upon ſuch bodies as are beſt ſuited to ſupport the young they contain. If fleſh meat be well waſhed, and left to putrefy under a ſieve, it will paſs through all the degrees of putrefaction without the appearance of worms. It has been obſerved that worms are of a different ſpecies, according to the nature of the diſeaſe, and the kind of animal which putrefies. The exhalation which ariſes from bodies in theſe different caſes, attracts different ſpecies of inſects, according to its nature. The opinion of thoſe who believe in ſpontaneous generation appears to Chaptal to be contrary to the experience and wiſdom of nature, which cannot have committed the reproduction and number of the ſpecies to chance. The progreſs of nature is the ſame for all the claſſes of individuals; and ſince it is proved that all the known ſpecies are re-produced in one and the ſame manner, how can we ſuppoſe that nature departs from her plain and general laws for the ſmall number of individuals whoſe generation is leſs known to us?

Becher had the courage to make obſervations, during the courſe of a year, upon the decompoſition of a carcaſe in the open air; and to obſerve all the phænomena. The firſt vapour which riſes, ſays he, is ſubtile and nauſeous: ſome days after it has a certain ſour and penetrating ſmell. After the firſt weeks, the ſkin becomes covered with a down, and appears yellowiſh; greeniſh ſpots are formed in various places, which afterwards become livid and black; a thick moſſy or mouldy ſubſtance then covers the greateſt part of the body; the ſpots open, and emit a ſanies.

Carcaſes buried in the earth preſent very different phænomena; the decompoſition in a burying-ground is at leaſt four times as ſlow. It is not perfectly ended, according to Mr. Petit, till three years after the body has been interred, at the depth of four feet; and it is ſlower in proportion as the body is buried at a greater depth. Theſe facts agree with the principles which we have already eſtabliſhed for bodies buried in the earth, and ſubjected to laws of decompoſition very different from thoſe which take place in bodies expoſed to the open air. In this caſe the decompoſition is favoured by the waters which filter through the earth, and diſſolve and carry with them the animal juices. It is alſo favoured by the earth, which abſorbs the juices with more or leſs facility. Meſſrs. Lemery, Geoffroy, and Hunaud have proved that argillaceous earths exert a very ſlow action upon bodies; but when the earths are porous and light, the bodies then dry very ſpeedily. The ſeveral principles of bodies abſorbed by the earth, or carried by the vapours, are diſperſed through a great ſpace, imbibed by the roots of vegetables, and gradually decompoſed. This is what paſſes in burying-grounds in the open air; but it is very far from being applicable to the ſepulchres which are made in churches and covered places. Here is neither water nor vegetation; and conſequently no cauſe which can carry away, diſſolve, or change the nature of the animal fluids: and it is an inſtance of wiſdom in the French government, that has prohibited the burying in churches; a practice which was once a ſubject of horror and infection.

The accidents which have happened at the opening of graves and vaults are but too numerous, to render any apology neceſſary for our ſpeaking a few words reſpecting the method of preventing them.

The decompoſition of a body in the bowels of the earth can never be dangerous, provided it be buried at a ſufficient depth, and that the grave be not opened before its entire and complete decompoſition. The depth of the grave ought to be ſuch that the external air cannot penetrate it; that the juices with which the earth is impregnated may not be conveyed to its ſurface; and that the exhalations, vapours, or gaſes, which are developed or formed by decompoſition, ſhould not be capable of forcing the earthy covering which detains them. The nature of the earth in which the grave is dug, influences all its effects. If the ſtratum which covers the body be argillaceous, the depth of the grave may be leſs, as this earth difficultly affords a paſſage to gas and vapour; but in general it is admitted to be neceſſary that bodies ſhould be buried at the depth of five feet, to prevent all theſe unhappy accidents. It is likewiſe neceſſary to attend to the circumſtance, that a grave ought not to be opened before the complete decompoſition of the body. This decompoſition, according to Mr. Petit, is not perfect until the expiration of three years, in graves of four feet depth; or four years, when they are ſix feet deep. This term affords many varieties, according to the nature of the earth, and the conſtitution of the ſubjects buried in it; but we may conſider it as a medium. The pernicious cuſtom which allows a ſingle grave to families more or leſs numerous, ought, therefore, to be ſuppreſſed; for in this caſe the ſame grave may be opened before the time preſcribed. Theſe are abuſes which ought to occupy the attention of government; and it is time that the vanity of individuals ſhould be ſacrificed to the public ſafety. It is likewiſe neceſſary to prohibit burying in vaults, and even in coffins. In the firſt caſe, the principles of the bodies are ſpread into the air, and infect it; in the ſecond, their decompoſition is ſlower and leſs perfect.

If theſe precautions be neglected; if the dead bodies be heaped together in too confined a ſpace; if the earth be not proper to abſorb the juices, and decompoſe them; if the grave be opened before the entire decompoſition of the body—unhappy accidents will, no doubt, be produced; and theſe accidents are but too common in great towns where every wiſe precaution is neglected. An inſtance of this happened when the ground of the church of St. Benoit at Paris was dug up a few years ago; a nauſeous vapour was emitted, and ſeveral of the neighbours were affected by it. The earth which was taken out of this grave was unctuous, viſcid, and emitted an infectious ſmell. Meſſrs. Maret and Navier have left us ſimilar obſervations.

Boyle relates that he has preſerved lemons, oranges, and other fruits from putrefaction, or other fermentation, during ſeveral years, by including them in an exhauſted receiver. Doctor Macbride found that putrefaction was accelerated by encloſing a piece of fleſh in an exhauſted receiver; but that another piece continued ſweet, which was included in an exhauſted hollow braſs ſphere, conſiſting of two hemiſpheres joined together. He conjectures that the cauſe of this difference might be, that in the latter experiment the vacuum was more perfect

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than in the former, as the glaſs receiver did not ſeem to exclude with ſufficient accuracy the external air; and though a partial vacuum may accelerate putrefaction, yet ſome air may be neceſſary to this proceſs.

It is well known that bodies are preſerved from putrefaction by covering them with wax, ſuet, &c. Whether is this effect produced merely by excluding external air, or by preventing the extrication of the gas, or both?

Sir John Pringle has made experiments to determine the powers of certain ſubſtances to promote or prevent putrefaction. From theſe experiments he has formed the following table, ſhewing the relative antiſeptic powers of the ſaline ſubſtances mentioned. Having found that two drams of beef put in a phial with two ounces of water, and placed in a heat equal to ninety degrees of Fahrenheit's thermometer, became putrid in fourteen hours, and that ſixty grains of ſea-ſalt preſerved a ſimilar mixture of beef and water more than thirty hours, he made the antiſeptic power of the ſea-ſalt a ſtandard, to which he compared the powers of the other ſalts. The algebraic character + ſignifies, that the ſubſtance to which it is annexed had a greater antiſeptic power than is expreſſed by the numbers.

Sea-ſalt, or the ſtandard	1
Sal-gem	1+
Vitriolated tartar	2
Spiritus Mindereri, or diſtilled vinegar ſaturated with volatile alkali	2
Soluble tartar	2
Sal diureticus, or muriated vegetable alkali	2+
Crude ſal ammoniac	3
Saline mixture	3
Nitre	4+
Salt of hartſhorn	4+
Salt of wormwood	4+
Borax	12
Salt of amber	20
Alum	30

N. B. The quantities of ſpiritus Mindereri and of the ſaline mixture were ſuch, that each of them contained as much alkaline ſalt as the other neutral ſalts.

Myrrh, aloes, aſſafetida, and terra Japonica, were found to have an antiſeptic power thirty times greater than the ſtandard. Gum ammoniacum and ſagapenum ſhewed little antiſeptic power.

Of all reſinous ſubſtances, camphor was found to reſiſt putrefaction moſt powerfully. Sir John Pringle believes that its antiſeptic power is 300 times greater than that of ſea-ſalt.

Chamomile flowers, Virginian ſnake-root, pepper, ginger, ſaffron, contrayerva root, and galls were found to be twelve times more antiſeptic than ſea-ſalt.

Infuſions of large quantities of mint, angelica, ground-ivy, green tea, red-roſes, common wormwood, muſtard, and horſe-radiſh, and alſo decoctions of poppy-heads, were more antiſeptic than ſea-ſalt.

Decoctions of wheat, barley, and other farinaceous grains, checked the putrefaction by becoming ſour.

Chalk, and other abſorbent powders, accelerated the putrefaction, and reſolved meat into a perfect mucus. The ſame powders prevented an infuſion of farinaceous grains from becoming mucilaginous and ſour.

One dram of ſea-ſalt was found to preſerve two drams of freſh beef in two ounces of water, above thirty hours, uncorrupted, in a heat equal to that of the human body, or above twenty hours longer than meat is preſerved in water without ſalt: but half a dram of ſalt did not preſerve it more than two hours longer than pure water. Twenty-five grains of ſalt had little or no antiſeptic quality. Twenty grains, fifteen grains, but eſpecially ten grains only of ſea-ſalt were found to accelerate and heighten the putrefaction of two drams of fleſh. Theſe ſmall quantities of ſea-ſalt did alſo ſoften the fleſh more than pure water.

The ſame learned and ingenious phyſician made experiments to diſcover the effects of mixing vegetable with animal matters.

Two drams of raw beef, as much bread, and an ounce of water, being beat to the conſiſtence of pap, and expoſed to ninety degrees of heat, according to Fahrenheit's thermometer, began to ferment in a few hours, and continued in a fermentation during two days. When it began to ferment and ſwell, the putrefaction had begun; and in a few hours afterwards the ſmell was offenſive. Next day the putrid ſmell ceaſed, and an acid taſte and ſmell ſucceeded. Freſh alimentary vegetables, as ſpinach, aſparagus, ſcurvy-graſs, produced ſimilar effects as bread on fleſh, but in a weaker degree. From ſeveral other experiments he found that animal ſubſtances excite the fermentation of vegetable ſubſtances, and that the latter ſubſtances correct the putreſcency of the former.

By adding ſaliva to a ſimilar mixture of fleſh, bread, and water, the fermentation was retarded, moderated, but rendered of twice the uſual duration, and the acid produced at laſt was weaker than when no ſaliva was uſed.

By adding an oily ſubſtance to the common mixture of fleſh, bread and water, a ſtronger fermentation was produced, which could not be moderated by the quantity of ſaliva uſed in the former experiment, till ſome fixed alkaline ſalt was added; which ſalt was found, without ſaliva, to ſtop ſuddenly very high fermentations.

He did not find that ſmall quantities of the following ſalts, ſal ammoniac, nitre, vitriolated tartar, ſal diureticus, ſalt of hartſhorn, ſalt of wormwood, were ſeptic, as ſmall quantities of ſea-ſalt were.

Sugar was found to reſiſt putrefaction at firſt, as other ſalts do, and alſo to check the putrefaction after it had begun by its own fermentative quality, like bread, and other fermentative vegetables.

Lime-water made ſome ſmall reſiſtance to putrefaction.

Port-wine, ſmall-beer, infuſions of bitter vegetables, of bark, and the juice of antiſcorbutic plants, retarded the fermentation of mixtures of fleſh and bread. But an unſtrained decoction of bark conſiderably increaſed that fermentation.

Crabs-eyes accelerated and increaſed the fermentation of a mixture of fleſh and bread.

Lime-water neither retarded nor haſtened the fermentation of ſuch a mixture: but when the fermentation ceaſed, the liquor was neither putrid nor acid, but ſmelled agreeably.

Fleſh pounded in a mortar was found to ferment ſooner than that which had not been bruiſed.

The tough inflammatory cruſt of blood was found to be moſt putreſcent, next to which the craſſamentum, or red coagulated maſs, and laſtly the ſerum.

Dr. Macbride's experiments confirm many of theſe above related, eſpecially thoſe which ſhow that the fermentation of vegetable ſubſtances is increaſed by a mixture of animal or putreſcent matter; that the putreſcency of the latter is corrected by the fermentative quality of the former; and that the putrefaction and fermentation of mixtures of animal and vegetable ſubſtances were accelerated by additions of abſorbent earths and of Peruvian bark; he alſo found, that although unburnt calcareous earths were ſeptic, quick-lime and lime-water prevented putrefaction, but that they deſtroyed or diſſolved the texture of fleſh.

The experiments of the author of the Eſſai pour ſervir à l' Hiſtoire de la Putrefaction, ſhew that metallic ſalts, reſinous powders, extracts of bark, and opium, are very powerfully antiſeptic, and that ſalts with earthy baſes are leſs antiſeptic than any other ſalts.

PUTTY. The calx of tin known by the name of putty, is generally uſed to poliſh various hard bodies, as glaſs, metallic ſpecula for reflecting teleſcopes, &c. When fuſed with lead and ſand it produces enamel; and ſerves alſo to cover earthen ware, giving to it a glaſſy and neat ſurface for uſe.

PUZZOLANA. This is a volcanic production of a gray, brown, yellowiſh, or blackiſh colour, looſe, granular, or duſty and rough, porous and ſpungy, reſembling a clay hardened in fire, and then reduced to a groſs powder. It contains, mixed with it, various heterogeneous ſubſtances: its ſpecific gravity is from 2, 5 to 2, 8, and it is in ſome degree magnetic: it ſcarcely efferveſces with acids, though partially ſoluble in them: it melts eaſily per ſe: but its moſt diſtinguiſhing property is, that it hardens very ſuddenly when mixed with $\frac{1}{3}$ of its weight of lime and water, and forms a cement, which is more durable in water than any other. According to Bergman's analyſis, one hundred parts of it contain from 55 to 60 of ſiliceous earth, 19 or 20 of argillaceous, 5 or 6 of calcareous, and from 15 to 20 of iron. It is evidently a martial argillaceous marl that has ſuffered a moderate heat. Its hardening power ariſes from the dry ſtate of the half-baked argillaceous particles, which makes them imbibe water very rapidly, and thus accelerates the deſiccation of the calcareous part; and alſo from the quantity and ſemi-phlogiſticated ſtate of the iron contained in it. It is found not only in Italy, but alſo in France, in the provinces of Auvergne and Limoges, and alſo in England, and elſewhere.

PYRITACEOUS LIMESTONE. This ſtone is called by the French Pierre de St. Ambroix. It is of an iron-gray colour, interſperſed with ſhining particles. Its texture is compact, and ſcarcely gives fire with ſteel. Its ſpecific gravity is 2,7034.

It is ſoluble in acids, and moſtly with effervеſcence: calcines in a ſtrong fire: makes nitre ſlightly detonate: and if diſtilled, affords a ſmall portion of vitriolic acid, and ſome ſulphur ſublimes.

Its component parts are 75 of mild calcareous earth, and 25 of pyrites, in which are contained 14 of argill, 7 of quartz and ſulphur, and 4 of iron.

PYRITES. Certain metallic combinations, which contain a very large proportion of ſulphur, are known by this name. They are not indeed entitled to any particular claſs diſtinct from ores; yet their abundance and other properties are ſufficient to juſtify the inſertion of a ſeparate article *.

Although ſometimes pyrites contains more metal than ſome ores, yet generally

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* From Macquer.

it contains leſs metal, and a larger quantity of mineralizing ſubſtances, ſulphur and arſenic, and particularly of unmetallic earth. The connexion of theſe matters is alſo much ſtronger in pyrites than in ores, and they are accordingly much harder; ſo that almoſt every pyrites can ſtrike ſparks from ſteel. From this property of ſtriking ſparks from ſteel they have been called pyrites, which is a Greek word ſignifying fire-ſtone. Pyrites was formerly uſed for fire-arms, as we now uſe flints; hence it was called carabine-ſtone. It is ſtill named by ſome, marcaſite. Perhaps no other kind of natural body has received ſo many names. Perſons curious to know the other names leſs uſed than thoſe we have mentioned, may find them in Henckel's Pyritologia. We think, with that celebrated chemiſt, that the ſubject has been perplexed by this multiplicity of names; for before his great and excellent work, the notions concerning pyrites were very confuſed and inaccurate.

Pyrites differs alſo from ores by its forms and poſitions in the earth. Although pyritous minerals generally precede, accompany, and follow veins of ores; they do not, properly ſpeaking, themſelves form the oblong and continued maſſes called veins, as ores do, but they form maſſes ſometimes greater and ſometimes ſmaller, but are always diſtinct from each other. Large quantities of them are often found unaccompanied by ores. They are formed in clays, chalk, marles, marbles, plaſters, alabaſters, ſlates, ſpars, quartz, granites, cryſtals, in a word, in all earths and ſtones. Many of them are alſo found in pit-coals, and in other bituminous matters.

Pyrites is alſo diſtinguiſhable from ores by its luſtre and figure, which is almoſt always regular and uniform, externally or internally, or both. Some ores, indeed, like thoſe of lead, many ores of ſilver, and ſome others, have regular forms, and are in ſome manner cryſtallized; but this regularity of form is not ſo univerſal, and ſo conſpicuous in ores as in pyrites. The luſtre of pyrites ſeems to be cauſed by its hardneſs, and the regularity of its form by the quantity of mineralizing ſubſtances which it contains.

By all theſe marks we may eaſily, and without analyſis, diſtinguiſh pyrites from true ores. When we ſee a mineral that is heavy, poſſeſſed of metallic luſtre, and of any regular form, the maſs of which appears evidently to be entire, that is, not to have been a fragment of another maſs, and which is ſo hard as to be capable of ſtriking ſparks from ſteel, we may be aſſured that ſuch a mineral is a pyrites, and not an ore.

The claſs of pyrites is very numerous, various, and extenſive. They differ one from another in the nature and proportions of their component parts, in their forms, and in their colours. The forms of theſe minerals are exceedingly various. No ſolid regular or irregular can eaſily be conceived that is not perfectly imitated by ſome kind of pyrites. They are ſpherical, oval, cylindrical, pyramidal, priſmatical, cubic; they are ſolids with 5, 6, 7, 8, 9, 10, &c. ſides. The ſurface of ſome is angular, and conſiſts of many baſes of ſmall pyramids, while their ſubſtance is compoſed of theſe pyramids, the points of which all unite in the centre of the maſs.

Pyritous minerals differ alſo in their component ſubſtances. Some of them are called ſulphureous, martial, cupreous, arſenical, as one or other of theſe ſubſtances predominate. We muſt obſerve with Henckel, whoſe authority is very great on this ſubject, that in general all pyrites are martial, as ferruginous earth is the eſſential and fundamental part of every pyrites. This earth is united with an unmetallic earth, with ſulphur or arſenic, or with both theſe matters; in which caſe the ſulphur always predominates over the arſenic, as Henckel obſerves. He conſiders theſe as the only eſſential principles of pyrites, and believes that all the other matters, metallic or unmetallic, which are found in it, are only accidental; amongſt which he even includes copper, although ſo much of it exiſts in ſome kinds of pyrites, that theſe are treated as ores of copper, and ſometimes contain even 50lb. of copper each quintal. Many other metals, even gold and ſilver, are ſometimes combined in pyrites; but theſe are leſs frequent, and the precious metals always in very ſmall quantities; they are therefore juſtly to be conſidered as accidental to pyrites. The different ſubſtances compoſing pyrites ſenſibly affect its colours. Henckel diſtinguiſhes them in general into three colours, white, yellowiſh or a pale yellow, and yellow. He informs us, that theſe three colours are often ſo blended one with another, that they cannot be eaſily diſtinguiſhed, unleſs when compared together.

The white pyrites contain moſt arſenic, and are ſimilar to cobalt and other minerals abounding in arſenic. The Germans call them miſpickel, or miſpilt. Iron and arſenic form the greateſt part of this pyrites. As arſenic has the property of whitening copper, ſome pyritous minerals almoſt white, like that of Chemnitz in Miſnia, are found to contain forty pounds of copper per quintal, and which are ſo much whitened by the arſenic that they are very like white pyrites. But Henckel obſerves, that theſe pyritous matters are very rare, and are never ſo white as the true white pyrites, which is only ferruginous and arſenical.

Yellowiſh pyrites is chiefly compoſed of ſulphur and iron. Very little copper and arſenic are mixed with any pyrites of this colour, and moſt of them contain none of theſe two metallic ſubſtances. This is the moſt common kind of pyrites: it is to be found almoſt everywhere. Its forms are chiefly round, ſpherical, oval, flattened, cylindrical; and it is compoſed internally of needles or radii, which unite in the centre or in the axis of the ſolid.

Yellow pyrites receives its colour from the copper and ſulphur which enter into its compoſition. Its colour, however, is inclined to a green, but is ſufficiently yellow to diſtinguiſh it from the other two kinds of pyrites, particularly when they are compared together. To make this compariſon well, the pyrites muſt be broken, and the internal ſurfaces muſt be placed near each other. The reaſon of this precaution is, that the colour of minerals is altered by expoſure to the air.

Perſons accuſtomed to theſe minerals can eaſily diſtinguiſh them. The chief difficulty is to diſtinguiſh white pyrites from cobalt and other minerals, which alſo contain ſome copper, and much arſenic.

Hence then we ſee, that arſenic is the cauſe of whiteneſs in pyrites, and is contained in every pyrites of that colour; that copper is the principal cauſe of the yellow colour of pyrites, and that every pyrites which is evidently yellow contains copper; that ſulphur and iron produce a pale yellow colour, which is alſo produced by copper and arſenic; hence ſome difficulty may ariſe in diſtinguiſhing pyrites from its colours. We may alſo obſerve, that ſulphur and arſenic, without any other ſubſtance, form a yellow compound, as we ſee from the example of orpiment or yellow arſenic. Thus, although the colours of the pyrites enable us to diſtinguiſh its different kinds, and to know their nature at firſt ſight, particularly when we have been accuſtomed to obſerve them; yet we cannot be entirely certain concerning the true nature of theſe minerals, and even of all minerals in general, that is, to know preciſely the kinds and proportions of their component ſubſtances, but by chemical analyſis and decompoſition.

Beſides the above-mentioned matters which compoſe pyrites, it alſo contains a conſiderable quantity of unmetallic earth, that is, an earth which cannot by any proceſs be reduced to metal. Henckel, Cramer, and all thoſe who have examined this matter, mention this earth, and prove its exiſtence.

We ought to obſerve, that this earth is combined with the other principles of the pyrites, and not merely interpoſed between its parts. It muſt therefore be diſtinguiſhed from other earthy and ſtony matters mixed accidentally with pyrites, and which do not make a part of the pyrites, ſince they may be ſeparated by mechanical means, and without decompoſing that mineral: but the earth of which we now treat is intimately united with the other conſtituent parts of the pyrites, is even a conſtituent part of pyrites, and eſſential to the exiſtence of this mineral, and cannot be ſeparated but by a total decompoſition of it.

According to Henckel, this unmetallic earth abounds much in the white pyrites, ſince he found from the analyſis which he made, that the iron, which is the only metal exiſting in theſe pyrites, is only about $\frac{1}{20}$ part of the fixed ſubſtance that remains after the arſenic has been expelled by torrefaction or ſublimation.

A much larger quantity of iron is in the pale yellow pyrites, according to Henckel. The proportion of iron is generally about twelve pounds to a quintal of pyrites, and ſometimes fifty or ſixty pounds: this is therefore called martial pyrites. It contains about $\frac{1}{4}$ of its weight of ſulphur, and the reſt is unmetallic earth.

The quantity of unmetallic earth contained in the yellow or cupreous pyrites, which are alſo martial, ſince, as we have obſerved, iron is an eſſential part of every pyrites, has not yet been determined. They probably contain ſome of that earth, though perhaps leſs of it than the others.

The nature of this unmetallic earth of pyrites has not been well examined. Henckel thinks that it is an earth diſpoſed already by nature to metallization, but not ſufficiently elaborated to be conſidered as a metallic earth. See the articles METALS and METALLIZATION. This opinion is not improbable; but as alum may be obtained from many pyrites, may we not ſuſpect that this unmetallic earth is of the nature of the baſis of alum or argillaceous earth? See ALUM and CLAY. Perhaps alſo this earth is different in different kinds of pyrites. The ſubject deſerves to be well examined.

Although pyrites is not ſo valuable as true ores, becauſe in general it contains leſs metal, and but exceedingly little of the precious metals; and becauſe its metallic contents are ſo difficult to be extracted that, excepting cupreous pyrites, which is called pyritous copper ore, it is not worked for the ſake of the contained metal; yet it is applied to other purpoſes, and furniſhes us with many uſeful ſubſtances; for from it we obtain all our green and blue vitriols, much ſulphur, arſenic, alum, and orpiment. See the principal proceſſes by which theſe ſubſtances are extracted from pyrites, under the article SMELTING of ORES.

As every pyrites contains iron, and moſt of them contain alſo ſulphur; as the pyrites moſt frequently found contains only theſe two ſubſtances with the unmetallic earth; and as iron and ſulphur have a ſingular action upon each other, when they are well mixed together and moiſtened; hence many kinds of pyrites, particularly thoſe which contain only the principles now mentioned, ſuſtain a ſingular alteration, and even a total decompoſition, when expoſed during a certain time to the combined action of air and water. The moiſture gradually penetrates them, divides, and attenuates their parts; the acid of the ſulphur particularly attacks the martial earth, and alſo the unmetallic earth; its unflammable principle is ſeparated from it, and is diſſipated. While theſe alterations happen, the pyrites changes its nature. The acid of the ſulphur which is decompoſed forms with the fixed principles of the pyrites, vitriolic, aluminous, and ſelenitic ſalts; ſo that a pyrites, which was once a ſhining, compact, very hard mineral, becomes in a certain time a grayiſh, ſaline, powdery maſs, the taſte of which is ſaline, auſtere, and ſtiptic.

Laſtly, if this maſs be lixiviated with water, cryſtals of vitriol, and ſometimes of alum, according to the nature of the pyrites employed, may be obtained by evaporation and cryſtallization.

This alteration and ſpontaneous decompoſition of pyrites is called eſfloreſcence and vitriolization; becauſe the pyrites becomes covered with a ſaline powder, and becauſe vitriol is always formed. This vitriolization is more or leſs quickly accompliſhed in pyrites according to its nature. It is a kind of fermentation excited by moiſture amongſt the conſtituent parts of theſe minerals; and it is ſo violent in thoſe which are moſt diſpoſed to it, that is, in the pale-yellow pyrites, which contain chiefly ſulphur and iron, that when the quantity of theſe is conſiderable, not only a ſulphureous vapour and heat may be perceived, but alſo the whole kindles and burns intenſely. The ſame phenomena are obſervable, and the ſame reſults are formed, by mixing well together and moiſtening a large quantity of filings of iron and powdered ſulphur; which experiment Lemeri has made, to explain the cauſes of ſubterranean fires and volcanoes.

We cannot doubt that, as the earth contains very large maſſes of pyrites of this kind, they muſt undergo the ſame changes when air and moiſture penetrate the cavities containing them; and the beſt natural philoſophers agree, that very probably this ſurpriſing decompoſition of pyrites is the cauſe of ſubterranean fires, of volcanoes, and of mineral waters, vitriolic, aluminous, ſulphureous, hot and cold.

No other pyrites is ſubject to this ſpontaneous decompoſition, when expoſed to humid air, but that which is both martial and ſulphureous, that is the pale yellow pyrites. The arſenical pyrites, or that which contains little or no ſulphur, is not changed by expoſure to air. This latter kind is harder, heavier, and more compact than the former. The pyrites which is angular and regularly ſhaped, is chiefly of this kind. Wallerius, in his Mineralogy, propoſes to diſtinguiſh this kind of pyrites by the name of marcaſite. When cut, it may be poliſhed ſo well as to give a luſtre almoſt equal to that of diamonds; but without refracting or decompoſing the light; for it is perfectly opake. It has been employed ſome years paſt in the manufacture of toys, as of buckles, necklaces, &c. and is called in commerce marcaſite. See WATERS (MINERAL). ORES. SMELTING of ORES.

PYROMETER. An inſtrument contrived for meaſuring the expanſions and contractions of bodies by change of temperature. See EXPANSION.

PYROMETER OF WEDGWOOD. In this article I have abridged the papers of the inventor in the Phil. Tranſ. vols. lxii and lxiv.

A meaſure for the higher degrees of heat, ſuch as the common thermometers afford for the lower ones, would be an important acquiſition both to the philoſopher and the practical artiſt. The latter muſt feel the want of ſuch a meaſure on many occaſions: particularly when he attempts to follow, or apply to uſe, the curious experiments of Mr. Pott, related in his Lithogeognoſia, and other modern writers upon ſimilar ſubjects. When we are told, for inſtance, that ſuch and ſuch materials were changed by fire into a fine white, yellow, green, or other coloured glaſs, and find that theſe effects do not happen, unleſs a particular degree of fire has fortunately been hit upon, which degree we cannot be ſure of ſucceeding in again—when we are diſappointed by having the reſult at ſome times an unvitrified maſs, and at others an over-vitrified ſcoria, from a little deficiency or exceſs of heat—when we ſee colours altered not only in ſhade but in kind, and in many caſes deſtroyed by a ſmall augmentation of the heat which had produced them—how much is it to be wiſhed that the authors had been able to convey to us a meaſure of the heat made uſe of in their valuable proceſſes!

Mr. Wedgwood, in a long courſe of experiments for the improvement of the manufacture he is engaged in, found ſome of his greateſt difficulties to ariſe from not being able to aſcertain the heat to which the experiment-pieces had been expoſed; and having no other reſource, he was obliged at firſt to content himſelf with ſuch meaſures as his own kilns and the different parts of them afforded. Thus the kiln in which his glazed ware is fired furniſhes three meaſures, the bottom being of one heat, the middle of a greater, and the top ſtill greater: the kiln in which the biſcuit ware is fired furniſhes three or four others, of higher degrees of heat; and by theſe he marked his regiſtered experiments. But theſe meaſures were neither fully adequate to his own views, nor capable of being communicated to others; their uſe is confined to a particular ſtructure of furnaces, and mode of firing; and upon any alteration in theſe, they would become uſeleſs and unintelligible, even where now they are beſt known. And indeed as this part of the operation is performed by workmen of the loweſt claſs, it is impoſſible to depend upon any great accuracy even in one and the ſame furnace. It has accordingly often happened, that the pieces fired in the top of the kiln in one experiment, have been made no hotter than thoſe fired in the middle in another, and vice verſa.

The force of fire, in its higher as well as lower ſtages, can no otherwiſe be juſtly aſcertained than by its effects upon ſome known body. Mr. Wedgwood obſerved that compoſitions of calces of iron with clay aſſumed, from different degrees of fire, ſuch a number of diſtinct colours and ſhades as promiſed to afford uſeful criteria of the reſpective degrees.

With this idea he prepared a quantity of ſuch a compoſition, and formed it into circular pieces, about an inch in diameter, and a quarter of an inch thick. A number of theſe was placed in a kiln, in which the fire was gradually augmented, with as much uniformity and regularity as poſſible, for near ſixty hours. The pieces, taken out at equal intervals of time during this ſucceſſive increaſe of heat, and piled in their order upon one another in a glaſs tube, exhibited a regular and pretty extenſive ſeries of colours; from a fleſh-colour to a deep browniſh-red, from thence to a chocolate, and ſo on to nearly black, with all the intermediate tints between theſe colours. A back being fixed to the tube, like the ſcale of a thermometer, and the number of the pieces marked upon it reſpectively oppoſite to them, it is obvious that theſe numbers may be conſidered as ſo many thermometric diviſions or degrees; and that, if another piece of the ſame compoſition be fired in any other kiln, or furnace, not exceeding the utmoſt heat of the firſt, it will acquire a colour correſponding to ſome of the pieces in the tube, and thus point out the degree of heat which that piece, and conſequently ſuch other matters as were in the fire along with it, have undergone.

It muſt however be confeſſed, that, for general uſe, a thermometer on this principle is liable to objection, as ideas of colours are not perfectly communicable by words; nor are all eyes, or all light, equally adapted for diſtinguiſhing them, eſpecially the ſhades, which approach near to one another; and the effects of phlogiſtic vapours, in altering the colour, may not in all caſes be eaſily guarded againſt.

In conſidering this ſubject attentively, another property of argillaceous bodies occurred to Mr. Wedgwood; viz. the dimunition of their bulk by fire. This he found to be a more accurate and extenſive meaſure of heat than the different ſhades of colour.

He found that this diminution takes place in a low red heat; and that it proceeds regularly, as the heat increaſes, till the clay becomes vitrified, and conſequently to the utmoſt degree that crucibles or other veſſels made of this material can ſupport. The total contraction of ſome good clays which he examined in the ſtrongeſt of his own fires, is conſiderably more than one-fourth part in every dimenſion.

If, therefore, we can procure at all times a clay ſufficiently apyrous or unvitreſcible, and always of the ſame quality in regard to contraction by heat; and if we can find means of meaſuring this contraction with eaſe and minute accuracy, Mr. Wedgwood thinks that we ſhall be furniſhed with a meaſure of fire ſufficient for every purpoſe of experiment or buſineſs.

We have in different parts of England immenſe beds of clay; each of which, at equal depths, is pretty uniform in quality throughout its whole extent. Mr. Wedgwood found, that ſome of the pureſt Corniſh porcelain clays ſeem the beſt adapted, both for ſupporting the intenſity, and meaſuring the degrees of fire.

For preparing and applying this material to thermometric purpoſes, he propoſes the following method.

The clay is firſt to be waſhed over, and, whilſt in a dilute ſtate, paſſed through a fine lawn. It muſt then be made dry, and put up in boxes.

While the clay is thus kept dry in boxes, as well as while it continues in its natural bed, it is ſecure from alterations in quality, which clays in general are ſubject to undergo when expoſed, for a long courſe of years, to the joint actions of air and moiſture. In the lawns, Mr. Wedgwood made uſe of, the interſtices were each leſs than the 100,000th part of an inch. If Mr. Wedgwood means, as I ſuppoſe he does, that the ſquare interſtices of his lawn were each leſs than the 100,000th part of a ſquare inch, the number of threads in an inch were about 320.

The dry clay is to be ſoftened for uſe with about two fifths of its weight of water; and formed into ſmall pieces, in little moulds of metal ſix-tenths of an inch in breadth, with the ſides pretty exactly parallel, this being the dimenſion intended to be meaſured, about four-tenths of an inch deep, and one inch long. To make the clay deliver eaſily, it will be neceſſary to oil the mould, and make it warm.

Theſe pieces, when perfectly dry, are put into another iron mould or gage, conſiſting only of a bottom, with two ſides, five-tenths of an inch deep; to the dimenſions of which ſides the breadth of the pieces is to be pared down.

For meaſuring the diminution which they are to ſuffer from the action of fire, another gage is made, of two pieces of braſs, twenty-four inches long, with the ſides exactly ſtraight, divided into inches and tenths, fixed five-tenths of an inch aſunder at one end, and three-tenths at the other, upon a braſs plate, ſo that one of the thermometric pieces, when pared down in the iron gage, will juſt fit to the wider end. Let us ſuppoſe this piece to have diminiſhed in the fire one-fifth of its bulk, it will then paſs on to half the length of the gage; if diminiſhed two-fifths, it will go on to the narroweſt end; and in any intermediate degree of contraction, if the piece be ſlid along till it reſts againſt the converging ſides, the degree at which it ſtops will be the meaſure of its contraction, and conſequently of the degree of heat it has undergone.

Theſe are the outlines of what appeared to Mr. Wedgwood neceſſary for the making and uſing of this thermometer; and he expreſſes his hope that the whole proceſs will be found ſufficiently ſimple and eaſy of execution. It may nevertheleſs be proper to take notice of a few minuter circumſtances, and to mention ſome obſervations which occurred in the progreſs of the inquiry.

As there ought to be a certainty of the clay being eaſily and at all times procurable in ſufficient quantity, and on moderate terms, Mr. Wedgwood offered to the Royal Society a ſufficient ſpace in a bed of the Cornwall clay to ſupply the world with thermometric pieces for numerous ages.

In order to be aſſured that the clay made uſe of for theſe thermometers is perfectly ſimilar, it will be beſt to dig it out of the earth in conſiderable quantity at once, an extent of ſome ſquare feet or yards in area, and to the depth of ſix or ſeven yards or more from the ſurface, and to mix the whole thoroughly together, previous to the further preparation already mentioned.

This clay, dried by the ſummer heat, or in a moderately warm room, or with more heat before a fire, has not been obſerved to differ in degree of dryneſs. After being ſo dried, it loſes about a hundredth part of its weight in the heat of boiling water, about as much more in that of melted lead, and from thence to a red heat ten parts, in all $\frac{12}{100}$. Each of theſe heats ſoon expels from the clay its determinate quantity of matter, chiefly air; after which, the ſame heat, though continued for many hours, has no further effect. Mr. Wedgwood had ſome hopes that the gradation of the common thermometer might be continued, upon this principle, up to the red-heat at which the ſhrinking of the clay commences, ſo as to connect the two thermometers together by one ſeries of numbers; but the loſs of weight appears not to be ſufficiently uniform or proportional to the degree of heat to anſwer that purpoſe, for it was found to go on quicker, and bladders tied to the mouths of the veſſels in which the pieces were heated, became more rapidly diſtended at the commencement of redneſs than at any other time. From low red-heat to a ſtrong one, ſuch as copper melts in, the loſs of weight was only about two parts in a hundred; though the difference between theſe two heats appears to be much greater than what the ſame loſs correſponds to in the lower ſtages. After this period, the decreaſe of weight entirely ceaſed.

The vapours expelled from the clay, caught ſeparately in the different degrees of heat, ſeemed, from the few trials made with them, to conſiſt of common air mixed with fixed air. They all precipitated lime-water, that which was firſt extricated exceeding weakly, the others more and more conſiderably; but the laſt not near ſo ſtrongly as the air expelled from lime-ſtone in burning. None of them were inflammable.

The thermometric pieces may be formed much more expeditiouſly than in the ſingle mould, by means of an inſtrument uſed for ſimilar purpoſes by potters. It conſiſts of a cylindrical iron veſſel, with holes in the bottom, of the form and dimenſions required. The ſoft clay put in the veſſel is forced by a preſs down through theſe apertures, in long rods, which may be cut while moiſt, or broken when dry, into pieces of convenient lengths. It was hoped that this method would of itſelf have been ſufficient, without the addition of the paring gage, making proper allowance, in the ſize of the holes, for the ſhrinking of the clay in drying. But it was found that a variety of little accidents might happen to alter the ſhape and dimenſions of the pieces, in a ſenſible degree, while in their ſoft ſtate; ſo that it will be always ſafeſt to have recourſe to the paring gage for aſcertaining and adjuſting their breadth when perfectly dry, this being the period at which the pieces are exactly alike with regard to their future diminiſhing; ſo that if they are now reduced to the ſame breadth, we may be ſure that they will ſuffer equal contractions from equal degrees of heat afterwards, whether they have been made in a mould, or by a preſs, or in any other way; neither is any variation in the length or thickneſs of theſe pieces of the leaſt conſequence, provided one of the dimenſions, that by which they are afterwards to be meaſured, is made accurate to the gage.

It will be proper to bake the pieces, when dry, with a low red-heat, in order to give them ſome firmneſs or hardneſs, that they may, if neceſſary, be able to bear package and carriage; but more eſpecially to prepare them for being put into an immediate heat, along with the matters they are to ſerve as meaſures to, without burſting or flying, as unburnt clay would do. We need not be ſolicitous about the preciſe degree of heat employed in this baking, provided only that it does not exceed the loweſt degree which we ſhall want to meaſure in practice; for a piece that has ſuffered any inferior degrees of heat, anſwers as well for meaſuring higher ones, as a piece which has never been expoſed to fire at all. In this part of the preparation of the pieces, it may be proper to inform the operator of a circumſtance which, though otherwiſe immaterial, might at firſt diſconcert him: if the heat is not in all of them exactly equal, he will probably find that while ſome have begun to ſhrink, others are rather enlarged in their bulk; for they all ſwell a little juſt on the approach of redneſs. As this is the period of the moſt rapid produce of air, the extenſion may perhaps be owing to the air having at this moment become elaſtic to ſuch a degree, as to force the particles of the clay a little aſunder before it obtains its own enlargement.

Each diviſion of the ſcale, though ſo large as a tenth of an inch, anſwers to a 600th part of the breadth of the little piece of clay. We might go to much greater nicety, either by making the diviſions ſmaller, or the ſcale longer; but it is not apprehended that any thing of this kind will be found neceſſary: and indeed, in proceeding much farther in either way, we may poſſibly meet with inconveniencies ſufficient to counterbalance the apparent additional accuracy of meaſurement.

The diviſions of this ſcale, like thoſe of the common thermometers, are unavoidably arbitrary; but the method here propoſed appears ſufficiently commodious and eaſy of execution, the diviſions being adjuſted by meaſures everywhere known, and at all times obtainable: for, however the inches uſed in different countries may differ in length, this cannot affect the accuracy of the ſcale, provided that the proportions between the wider and narrower end of the gage are exactly as five-tenths of thoſe inches to three-tenths, and the length 240 of the ſame tenths; and that the pieces in their perfectly dry ſtate, before firing, fit preciſely to the wider end. When one gage is accurately adjuſted to theſe proportional meaſures, two pieces of braſs ſhould be made, one fitting exactly into one end, and the other into the other; theſe will ſerve as ſtandards for the ready adjuſtment of other gages to the dimenſions of the original.

By this ſimple method we may be aſſured that thermometers on this principle, though made by different perſons, and in different countries, will all be equally affected by equal degrees of heat, and all ſpeak the ſame language: the utility of this laſt circumſtance is now too well known to need being inſiſted on.

If a ſcale two feet in length ſhould be reckoned inconvenient, it may be divided into two, of one foot each, by having three pieces of braſs fixed upon the ſame plate; the firſt and ſecond, five-tenths of an inch apart at one end, and four-tenths at the other; the ſecond and third, four-tenths at one end, and three-tenths at the other; ſo that the firſt reaches to the 120th diviſion, and the ſecond from thence to the 240th.

As this thermometer, like all others, can expreſs only the heat felt by itſelf, the operator muſt be careful to expoſe the pieces to an equal action of the fire with the body whoſe heat he wants to meaſure by them. In kilns, ovens, reverberatories, under a muffle, and wherever the heat is pretty ſteady and uniform, the means of doing this are too obvious to need being mentioned. But in a naked fire, where the heat is neceſſarily more fluctuating, and unequal in different parts of the fuel, ſome precaution will be required.

The thermometer-piece may generally be put into the crucible, along with the ſubject matter of the experiment. But where the matter is of ſuch a kind as to melt and ſtick to it, the piece may be previouſly incloſed in a little caſe made of crucible clay. The ſmallneſs of the pieces will admit of this being done without inconvenience, at leaſt in any but the ſmalleſt crucibles, as the pieces themſelves may be diminiſhed to any ſize that may be found proper, provided only that one of the dimenſions, five-tenths of an inch, be preſerved in the manner before mentioned.

For the very ſmalleſt ſort of crucibles, the caſe may be put in cloſe to the crucible, ſo as to form as it were an addition to its bulk on the outſide. If it be aſked, why the caſe is not always thus put in by the ſide of the crucible? it is anſwered, that in judging of the heat of large crucibles from a thermometer-piece placed on the outſide of them, we may ſometimes be deceived, as the piece in its little caſe has been found to heat ſooner than the matter in the larger veſſel; but in ſmall ones, as the crucible and caſe are nearly alike in bulk, there is little danger of error from this cauſe.

Theſe thermometer-pieces poſſeſs ſome ſingular properties, which we could not have expected to find united in any ſubſtance whatever, and which peculiarly fit them for the purpoſes they are here applied to.

1. When baked by only moderate degrees of fire, though they are, like other clays, of a porous texture, and imbibe water; yet, when ſaturated with the water, their bulk continues exactly the ſame as in a dry ſtate.

2. By very ſtrong fire, they are changed to a porcelain or ſemi-vitreous texture; nevertheleſs, their contraction, on further augmentations of the heat, proceeds regularly, as before, up to the higheſt degree of fire that Mr. Wedgwood has been able to produce.

3. They bear ſudden alternatives of heat and cold; may be dropped at once into intenſe fire; and, when they have received its heat, may be plunged as ſuddenly into cold water, without the leaſt injury from either.

4. Even while ſaturated with water in their porous ſtate, they may be thrown immediately into a white heat, without burſting or ſuffering any injury.

5. Sudden cooling, which alters both the bulk and texture of moſt bodies, does not at all affect theſe, at leaſt not in any quality ſubſervient to their thermometric uſes.

6. Nor are they affected by long continuance in, but ſolely by, the degree

of heat they are expoſed to. In three minutes, or leſs, they are perfectly penetrated by the heat which acts upon them, ſo as to receive the full contraction which that degree of heat is capable of producing, equally with thoſe which had undergone its action during a gradual increaſe of its force for many hours. Strong degrees of heat are communicated to them with more celerity than weak ones; perhaps the heat may be more readily tranſmitted, in proportion as the texture becomes more compact.

Theſe facts have been aſcertained by many experiments, the particulars of which are omitted, becauſe they would ſwell this article much beyond the bulk intended.

The uſe and accuracy of this thermometer for meaſuring, after an operation, the degree of heat which the matter has undergone, will be apparent. The foregoing properties afford means of meaſuring it alſo eaſily and expeditiouſly, during the operation, ſo that we may know when the fire is increaſed to any degree previouſly determined upon. The piece may be taken out of the fire in any period of the proceſs, and dropped immediately into water, ſo as to be fit for meaſuring by the gage in a few ſeconds of time. At the ſame inſtant, another piece may be introduced into the place of the former, to be taken out and meaſured in its turn; and thus alternately, till the deſired degree of heat is obtained. But as the cold piece will be two or three minutes in receiving the full heat, and correſponding contraction; to avoid this loſs of time, it may be proper on ſome occaſions to have two or more pieces, according to convenience, put in together at firſt, that they may be ſucceſſively cooled in water, and the degrees of heat examined at ſhorter intervals. It will be unneceſſary to ſay any thing further upon precautions or procedures which the very idea of a thermometer muſt ſuggeſt, and every experimenter will readily find means to obviate.

It only now remains, that the language of this new thermometer be underſtood, and that it may be known what the heats meant by its degrees really are. For this purpoſe a great number of experiments have been made, from which the following reſults are ſelected.

The ſcale commences at a red-heat, fully viſible in day-light; and the greateſt heat that Mr. Wedgwood obtained in his experiments is 160°. This degree he produced in an air furnace about eight inches ſquare.

Mr. Alchorne tried the neceſſary experiments with the pure metals at the Tower, to aſcertain at what degrees of this thermometer they go into fuſion; and it appears that Swediſh copper melts at 27, ſilver at 28, and gold at 32.

Braſs is in fuſion at 21. Nevertheleſs, in the braſs and copper founderies, the workmen carry their fires to 140° and upwards; but for what purpoſe they ſo far exceed the melting heat, or whether ſo great an additional melting heat be really neceſſary, Mr. Wedgwood ſays he has not learned.

The welding heat of iron is from 90 to 95; and the greateſt heat that could be produced in a common ſmith's forge 125.

Caſt-iron was found to melt at 130°, both in a crucible in Mr. Wedgwood's furnace, and at the foundery; but could not be brought into fuſion in the ſmith's forge, though that heat is only 5° lower. The heat by which iron is run down among the fuel for caſting is 150°.

As the welding ſtate of iron is a ſoftening or beginning fuſion of the ſurface, it has been generally thought that caſt-iron would melt with much leſs heat than what is neceſſary for producing this effect upon the forged; whereas, on the contrary,

trary, caſt-iron appears to require, for its fuſion, a heat exceeding the welding heat 35 or 40°, which is much more than the heat of melted copper exceeds the loweſt viſible redneſs.

Thus we find, that though the heat for melting copper is by ſome called a white heat, it is only 27° of this thermometer. The welding heat of iron, or 90°, is likewiſe a white heat; even 130°, at which caſt-iron is in fuſion, is no more than a white heat; and ſo on to 160° and upwards is all a white heat ſtill. This ſhews abundantly how vague ſuch a denomination muſt be, and how inadequate to the purpoſe of giving us any clear ideas of the extent of what we have been accuſtomed to conſider as one of the three diviſions of heat in ignited bodies.

A Heſſian crucible, in the iron foundery, viz. about 150° melted into a flag-like ſubſtance. Soft iron nails, in a Heſſian crucible in Mr. Wedgwood's furnace, melted into one maſs with the bottom of the crucible, at 154°: the part of the crucible above the iron was little injured.

The fonding heat of the glaſs furnaces Mr. Wedgwood examined, or that by which the perfect vitrification of the materials is produced, was at one of them 114° for flint-glaſs, and 124° for plate-glaſs; at another it was only 70° for the former, which ſhews the inequality of heat, perhaps unknown to the workmen themſelves, made uſe of for the ſame purpoſe. After complete vitrification, the heat is abated for ſome hours to 28 or 29°, which is called the ſettling heat; and this heat is ſufficient for keeping the glaſs in fuſion. The fire is afterwards increaſed, for working the glaſs, to what is called the working heat; and this Mr. Wedgwood found, in plate-glaſs, to be 57°.

Delft-ware is fired by a heat of 40 or 41°; cream-coloured or queen's-ware, by 86°; and ſtone-ware, called by the French pots de grès, by 102°; by this ſtrong heat, it is changed to a true porcelain texture. The thermometer-pieces begin to acquire a porcelain texture about 110°.

The above degrees of heat were aſcertained by thermometer-pieces fired along with the ware in the reſpective kilns. But this thermometer affords means of doing much more, and going further in theſe meaſures than could at firſt have been expected; it will enable us to aſcertain the heats by which many of the porcelains and earthen wares of diſtant nations and different ages have been fired: for as burnt clay, and compoſitions in which clay is a prevailing ingredient, ſuffer no diminution of their bulk by being repaſſed through degrees of heat which they have already undergone, but are diminiſhed by any additional heat, as has been before obſerved, if a fragment of them be made to fit into any part of the gage, and then fired along with a thermometer-piece till it begins to diminiſh, the degree at which this happens, points out the heat by which it had been fired before. Of ſeveral pieces of ancient Roman and Etruſcan wares, which Mr. Wedgwood examined, none appeared to have undergone a greater heat than 32°, and none leſs than 20°; for they all began to diminiſh at thoſe or the intermediate degrees.

By means of this thermometer, ſome intereſting properties of natural bodies may likewiſe be diſcovered or more accurately determined, and the genus of the bodies aſcertained. Jaſper, for inſtance, is found to diminiſh in the fire, like an artificial mixture of clay and ſiliceous matter; granite, on the contrary, has its bulk enlarged by fire, whilſt flint and quartzoſe-ſtones are neither enlarged nor diminiſhed. Theſe experiments were made in fires between 70 and 80° of this thermometer. A ſufficient number of facts like theſe, compared with each

other,

other, and with the properties of ſuch natural or artificial bodies as we wiſh to find out the compoſition of, may lead to various diſcoveries, of which Mr. Wedgwood ſays he has already found ſome promiſing appearances; but that many more experiments are wanting to enable him to ſpeak with that certainty and preciſion on theſe ſubjects which they appear to deſerve.

A piece of an Etruſcan vaſe melted completely at 33°; pieces of ſome other vaſes and Roman ware about 36°; Worceſter china vitrified at 94°; Mr. Sprimont's Chelſea china at 105°; the Derby at 112°; and Bow at 121°; but Briſtol china ſhewed no appearance of vitrification at 135°. The common ſort of Chineſe porcelain does not perfectly vitrify by any fire Mr. Wedgwood could produce; but began to ſoften about 120°, and at 156° became ſo ſoft as to ſink down, and apply itſelf cloſe upon a very irregular ſurface underneath. The true ſtone nankeen, by this ſtrong heat, does not ſoften in the leaſt; nor does it even acquire a porcelain texture, the unglazed parts continuing in ſuch a ſtate as to imbibe water and ſtick to the tongue. The Dreſden porcelain is more refractory than the common Chineſe, but not equally ſo with the ſtone nankeen. The cream-coloured or queen's ware bears the ſame heat as the Dreſden, and the body is as little affected by this intenſe degree of fire.

Mr. Pott ſays, that to melt a mixture of chalk and clay in certain proportions, which proportions appear from his tables to be equal parts, is among the maſterpieces of art. This mixture melts into a perfect glaſs at 123° of this thermometer.

The whole of Mr. Pott's or any other experiments may, by repeating and accompanying them with theſe thermometric pieces, have their reſpective degrees of heat aſcertained, and thereby be rendered more intelligible and uſeful to the reader, the experimenter, and the working artiſt.

Mr. Wedgwood found from the analyſis of the clay of which the thermometric pieces are formed, that it conſiſts of two parts of pure ſiliceous earth to three parts of pure argillaceous or aluminous earth.

Mr. Wedgwood afterwards endeavoured to connect his thermometer with that of Fahrenheit's, by means of a ſilver expanſion-piece as an intermediate meaſure. In order to procure a gage for this purpoſe like that by which the thermometer-pieces are meaſured, he made choice of tobacco-pipe clay, mixed with charcoal in fine powder, in the proportion of three parts of the charcoal to five of the clay by weight. By a free acceſs of air, in the burning by which the gage is prepared for uſe, the charcoal is conſumed, and leaves the clay extremely light and porous; from which circumſtance it bears ſudden alterations of cold and heat, often requiſite in theſe operations, much better than the clay alone.

A clear idea may be obtained of this ſpecies of gage, by conceiving two rulers or flat pieces a quarter of an inch thick fixed flat upon a ſmooth flat plate, a little further aſunder at one end than at the other; ſo that they may include between them a long converging canal, in which a piece of metal is ſo adjuſted as to fit exactly at the wider end of the canal, which is divided on one ſide into a number of ſmall equal parts, and which may be conſidered as performing the offices both of the tube and ſcale of the common thermometer. When a piece of metal is heated to an exact equality with the gage, the exceſs of the expanſion of one above the other can be meaſured, which is ſufficient for purpoſes where only an uniform and graduated effect of fire is required.

In order to obtain a correſponding interval between Fahrenheit's thermometer and this intermediate ſcale, the ſilver-piece and gage were laid together for ſome time in ſpring water, of the temperature of 50° of Fahrenheit: the point which the piece went to in this cold ſtate was marked (0) near the narrow end of the gage.

The heat of boiling water was taken without difficulty, by keeping the apparatus in boiling water itſelf during a ſufficient ſpace of time for the full heat to be communicated to it. The expanſion of the ſilver by this heat, that is, by an increaſe of the heat from 50° to 212°, or a period containing 162° of Fahrenheit, was juſt 8° of the gage or intermediate thermometer; whence one of theſe degrees, according to this experiment, contains juſt $20^\circ\frac{1}{4}$ of Fahrenheit.

For the boiling heat of mercury, it was neceſſary to proceed in a different manner; not to convey the heat from the mercury to the inſtrument, but to convey it equally to them both from another body. Mr. Wedgwood, therefore, made a ſmall veſſel for holding the mercury in the gage itſelf. The plate which forms the bottom of the canal, ſerves alſo for the bottom of the veſſel, which is ſituated cloſe to the ſide of the canal, and as near as poſſible to that part of it in which both the ſilver-piece, and the diviſions required for this particular experiment, are contained.

The gage, with ſome mercury in the veſſel, was laid upon a ſmooth and level bed of ſand, on the bottom of an iron muffle kept open at one end; the fire increaſed very gradually till the mercury boiled, and then continued ſteady, ſo as juſt to keep it boiling for a conſiderable time. The boiling heat of mercury was thus found to be $27^\circ\frac{1}{2}$ of the intermediate thermometer, which anſwering to an interval of 550° of Fahrenheit, makes one degree of this equal to juſt 20° of his.

The next object to be aſcertained was an interval of correſpondence between this intermediate gage and the thermometer for ſtrong fire.

In theſe experiments Mr. Wedgwood found it was impoſſible to obtain in common fires, or in common furnaces, an uniform heat through the extent even of a few inches. He, therefore, had recourſe to the fire of an enamelling oven, which was of ſuch a magnitude as to exceed perhaps ſome hundreds of times the bulk of the matters required to be heated. A muffle being placed in this furnace, the gage was fixed in it as before with the ſilver-piece. Some of the clay thermometer pieces were ſet on end upon the ſilver-piece, with that end of each downwards which is marked to go foremoſt in meaſuring it; that is, they were in contact with the ſilver in that part of their ſurface by which their meaſure is afterwards aſcertained.

The fire about the oven was ſlowly increaſed for ſome hours, and kept as even and ſteady as poſſible. Upon opening a ſmall door, which had been made for introducing the apparatus, and looking in from time to time, it was obſerved that the muffle, with the adjacent parts of the oven and ware, acquired a viſible redneſs at the ſame time; and in the progreſs of the operation, the eye could not diſtinguiſh the leaſt diſſimilarity in the aſpect of the different parts; whereas in ſmall fires, the difference not only between the two ends of the muffle, but in much leſs diſtances, is ſuch as to ſtrike the eye at once.

When the muffle appeared of a low red-heat, ſuch as was judged to come fully within the province of his thermometer, it was drawn forward towards the door of the oven; and its own door being then nimbly opened by an aſſiſtant, Mr. Wedgwood puſhed the ſilver-piece as far as it would go. But as the diviſion which it went to could not be diſtinguiſhed in that ignited ſtate, the muffle was lifted out, by means of an iron rod paſſed through two rings made for that purpoſe, with care to keep it ſteady, and avoid any ſhake that might endanger the diſplacing of the ſilver-piece.

When the muffle was grown ſufficiently cold to be examined, he noted the degree of expanſion which the ſilver-piece ſtood at, and the degree of heat ſhewn by the thermometer-pieces meaſured in their own gage; then returned the whole into the oven as before, and repeated the operation with a ſtronger heat, to obtain another point of correſpondence on the two ſcales.

The firſt was at 2°$\frac{1}{4}$ of his thermometer, which coincided with 66° of the intermediate one; and as each of theſe laſt has been before found to contain 20 of Fahrenheit's, the 66 will contain 1320; to which add 50, the degree of his ſcale to which the (0) of the intermediate thermometer was adjuſted, and the ſum 1370 will be the degree of Fahrenheit's correſponding to his 2°$\frac{1}{4}$.

The ſecond point of coincidence was at 6°$\frac{1}{4}$ of his, and 92° of the intermediate; which 92 being, according to the above proportion, equivalent to 1840 of Fahrenheit, add 50 as before to this number, and his 6°$\frac{1}{4}$ is found to fall upon the 1890th degree of Fahrenheit.

It appears from hence, that an interval of four degrees upon Mr. Wedgwood's thermometer is equivalent to an interval of 520° upon that of Fahrenheit; and conſequently one of the former to 130° of the latter; and that the (0) of Mr. Wedgwood correſponds to 1077°$\frac{1}{2}$ of Fahrenheit.

From theſe data it is eaſy to reduce either ſcale to the other through their whole range; and from ſuch reduction it will appear, that an interval of near 480° remains between them, which the intermediate thermometer ſerves as a meaſure for; that Mr. Wedgwood's includes an extent of about 32000 of Fahrenheit's degrees, or about 54 times as much as that between the freezing and boiling points of mercury, by which mercurial ones are naturally limited; that if the ſcale of Mr. Wedgwood's thermometer be produced downwards, in the ſame manner as Fahrenheit's has been ſuppoſed to be produced upwards, for an ideal ſtandard, the freezing point of water would fall nearly on 8° below (0) of Mr. Wedgwood's, and the freezing point of mercury a little below 80°$\frac{1}{2}$; and that, therefore, of the extent of now meaſurable heat, there are about $\frac{5}{10}$ths of a degree of his ſcale from the freezing of mercury to the freezing of water; 8° from the freezing of water to full ignition; and 160° above this to the higheſt degree he has hitherto attained.

Mr. Wedgwood concludes his account with the following Table of the effects of heat on different ſubſtances, according to Fahrenheit's thermometer, and his own.

	Fahr.	Wedg.
Extremity of the ſcale of his thermometer	32277°	240°
Greateſt heat of his ſmall air furnace -	21877	160
Caſt-iron melts - -	17977	130
Greateſt heat of a common ſmith's forge -	17327	125
Welding heat of iron, greateſt - -	13427	95
————————, leaſt - -	12777	90
Fine gold melts - -	5237	32
Fine ſilver melts - - -	4717	28
Swediſh copper melts - -	4587	27
Braſs melts - - - -	3807	21

	Fahr.	Wedg.
Heat by which his enamel colours are burnt on	1857	6
Red-heat fully viſible in day-light	1077	0
Red-heat fully viſible in the dark	947	1
Mercury boils	600	$3\frac{673}{1000}$
Water boils	212	$6\frac{658}{1000}$
Vital heat	97	$7\frac{542}{1000}$
Water freezes	32	$8\frac{42}{1000}$
Proof ſpirit freezes	0	$8\frac{289}{1000}$
The point at which mercury congeals, conſequently the limit of mercurial thermometers, about	40	$8\frac{596}{1000}$

In a ſcale of HEAT drawn up in this manner, the comparative extents of the different departments of this grand and univerſal agent are rendered conſpicuous at a ſingle glance of the eye. We ſee at once, for inſtance, how ſmall a portion of it is concerned in animal and vegetable life, and in the ordinary operations of nature. From freezing to vital heat is barely a five-hundredth part of the ſcale; a quantity ſo inconſiderable, relatively to the whole, that in the higher ſtages of ignition, ten times as much might be added or taken away, without the leaſt difference being diſcernible in any of the appearances from which the intenſity of fire has hitherto been judged of. From hence at the ſame time we may be convinced of the utility and importance of a phyſical meaſure for theſe higher degrees of heat, and the utter inſufficiency of the common means of diſcriminating and eſtimating their force. Mr. Wedgwood adds, that he has often found differences, aſtoniſhing when conſidered as a part of this ſcale, in the heats of his own kilns and ovens, without being perceivable by the workmen at the time, or till the ware was taken out of the kiln.

PYROPHORUS. By this name is denoted an artificial product, which takes fire or becomes ignited on expoſure to the air. Hence, in the German language, it has obtained the name of luft-zunder, or air-tinder. It is prepared from alum by calcination, with the addition of various phlogiſtic ſubſtances. Homberg was the firſt that obtained it, which he did accidentally in the year 1680, from a mixture of human excrement and alum, upon which he was operating by fire. This chemiſt, upon the ſtrength of ſome information communicated to him, was endeavouring to extract by diſtillation from human excrement an oil that ſhould tranſmute mercury into ſilver; in this attempt, however, he was diſappointed, as might naturally be expected. Lemeri the younger, afterwards, in the year 1713, ſhewed that it could not only be prepared from this ſubſtance, but alſo (on being previouſly mixed with alum) from various other bodies, that are capable of being charred. After this, M. de Savigny made it appear, that by the addition of any inflammable body whatever, a phoſphorus may be made of all ſuch ſubſtances as contain vitriolic acid combined either with earth, or with alkaline ſalt, or with a metallic ſubſtance. Notwithſtanding this, the preference is given to alum, becauſe its earth beſt retains the vitriolic acid in the fire, and hence the operation ſucceeds beſt with this ſalt*.

The preparation is managed in the following manner: Three parts of alum are mixed with from two to three parts of honey, or ſugar; and this mixture is dried over the fire in a glazed bowl, or an iron pan, diligently ſtirring it all the while with an iron ſpatula. At firſt this mixture melts, but by degrees it becomes thicker, ſwells up, and at laſt runs into ſmall dry lumps. Theſe are triturated to powder, and once more roaſted over the fire, till there is not the leaſt moiſture remaining in them, and the operator is well aſſured that it can liquify no more: the maſs now looks like a blackiſh powder of charcoal. For the ſake of avoiding the previous above-mentioned operation, from four to five parts of burned alum may be mixed directly with two of charcoal powdered. This powder is poured into a phial or matras, with a neck about ſix inches long. The phial, which however muſt be filled three-quarters full only, is then put into a crucible, the bottom of which is covered with ſand, and ſo much ſand is put round the former that the upper part of its body alſo is covered with it to the height of an inch; upon this the crucible, with the phial, is put into the furnace, and ſurrounded with red-hot coals. The fire being now gradually increaſed till the phial becomes red-hot, is kept up for the ſpace of about a quarter of an hour, or till a black ſmoke ceaſes to iſſue from the mouth of the phial, and inſtead of this, a ſulphureous vapour exhales, which commonly takes fire. The fire is kept up till the ſulphureous flame is no longer to be ſeen; upon this the calcination muſt be put an end to, and the phial cloſed for a ſhort time with a ſtopper of clay or loam. But as ſoon as the veſſel is become ſo cool as to be capable of being held in the hand, the phial is taken out of the ſand, and the powder contained in it transferred as faſt as poſſible from the phial into a dry and ſtout glaſs made warm, which muſt be ſecured with a glaſs ſtopper.

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* In this article, I follow Wiegleb, and the copious and excellent notes of Dr. Hopſon, and his anonymous friend upon the chapter on Pyrophori.

For the production of this pyrophorus, it is neceſſary, according to Wiegleb, that there ſhould be in its compoſition a newly generated ſulphur, an inflammable coal, concentrated matter of fire, and calcined earth of alum, or ſome other fixed body, with which the newly generated ſulphur may unite. Scheele concludes from his experiments, that fixed alkali is requiſite for the production of pyrophorus, and mentions the following as proofs of it: that from a mixture of liver of ſulphur with calcined alum, and a little powdered charcoal, he obtained, after calcination, a good pyrophorus. The ſame effect took place when he had mixed together and calcined a ſpoonful of finely triturated vitriolated tartar, with three ſpoonfuls of charcoal reduced to a fine powder; both theſe experiments Wiegleb found to be juſt as the author had related them; but nevertheleſs he does not conceive the neceſſity of fixed alkali, becauſe there are alſo pyrophori which do not contain any fixed alkali at all. Probably the alkali ſerves only to retain and fix the ſulphur in the ſame manner as the earth of alum does, and perhaps does this better, and therefore may be uſed in its place; to which purpoſe alſo ſeveral other ſubſtances ſeem to be adapted.

The opinions of philoſophers relative to this phenomenon are likewiſe different. Some chemiſts have pretended, with Savigny, that there is to be found in the pyrophorus a highly concentrated vitriolic acid, which greedily attracts the moiſture of the air, and is by this means ſo intenſely heated, that the ſulphur, together with the coaly ſubſtance, is inflamed by it. To this opinion however Wiegleb objects, becauſe there is no acid in the pyrophorus perceptible to the ſenſes; on the contrary, this ſubſtance has manifeſtly the taſte of liver of ſulphur, and diſſolves, like liver of ſulphur, without affording any other ſmell than that which accompanies every ſolution of hepar ſulphuris. For if an uncombined acid were contained in it, that peculiar volatile and ſuffocating ſulphureous vapour muſt inevitably be perceived, which is always produced upon the admixture of an acid with a ſolution of liver of ſulphur. And he demands, in what part of it ſhould this uncombined acid be contained? The quantity of acid that quits the earth of alum will either be converted into ſulphur, or muſt fly off from the maſs in conſequence of the heat employed in the preparation. If it be ſaid that it remains united with the earth of alum, in this caſe it would not be a diſengaged acid; and its property of rapidly attracting water, and conſequent incaleſcence, which have been adduced as the cauſes of this phenomenon, are annihilated. This caſe is alſo impoſſible upon the whole; as an aluminous compound and liver of ſulphur cannot be placed in contact with each other without the former decompoſing the latter, and accordingly the ſolution of pyrophorus is precipitated by a ſolution of alum, with a diſagreeable odour. There muſt therefore neceſſarily be another reaſon for the inflammation of this compound.

Scheele * expoſed pyrophorus to moiſt phlogiſticated air, without obſerving any ignition to enſue. Mr. Bewley † found that, notwithſtanding that by a repeated calcination of vitriolated tartar and charcoal much of the vitriolic acid was loſt, yet a pyrophorus might be obtained, with a freſh addition of powdered charcoal, and even with the addition of an alkaline ſubſtance that exceeded the whole of the acid in quantity. Mr. Bewley obtained a pyrophorus likewiſe from calcined vitriol, from aluminous earth as free as poſſible from vitriolic acid, and from crocus martis, by the calcination of theſe ſubſtances with powdered charcoal and vegetable alkali. He even made a good pyrophorus without any vitriolic acid, to which he gave the name of alkaline pyrophorus, in conſequence of his having obtained it by the calcination of the coal of blood with vegetable alkali, the colouring ſubſtance of which had been already extracted for the precipitation of the Pruſſian blue; whether the alkali employed was common alkali, or purified ſalt of tartar, or fixed nitre, the reſult was always the ſame: and it appears from other kinds of pyrophorus which do not contain any alum, that there are other ſubſtances beſides that yield pyrophori, without containing the leaſt particle of vitriolic acid.

The neceſſity for the preſence of moiſture, as well as of pure air, for the accenſion of pyrophori, appears evident from Scheele's experiments. This great obſerver, having made the air in a matras thoroughly dry with quick-lime, and two days afterwards put ſome pyrophorus in it, could not perceive that it even grew warm. On the other hand, when he put a wet ſponge into the matras, and carefully cloſed the latter, the pyrophorus kindled in the ſpace of a few minutes. The pyrophorus, however, would not by any means take fire in phlogiſticated air. On the other hand, Mr. Bewley's experiment, according to which the pyrophorus kindled on dry paper, or dry lint, and ſo near the fire that ſome dry cauſtic alkali placed in the ſame ſituation did not get any moiſture from the air (and likewiſe on a hot iron plate), ſeem to ſhew that the pyrophorus will kindle without attracting any moiſture from the air: but here it may be ſufficient to obſerve in general, that the motion of the heat, which is excited in the luminous pyrophorus, is the cauſe of the accenſion of this ſubſtance; and this motion of the heat may either ariſe, as in the experiments above-mentioned, from heat applied ab extra, or (as is the caſe when expoſed to the common temperature of

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* See Scheele's Chemical Obſervations and Experiments on Air and Fire, tranſlated by Dr. Forſter, ſec. 81. p. 128.

† In Prieſtley's Experiments and Obſervations on Air, vol. iii.

the atmoſphere) by attracting the moiſture of this latter. Mr. Bewley thinks that pyrophori have the power of decompoſing the atmoſpheric air, and of attracting the nitrous air from it, and by this means of exciting ſuch a heat that the inflammable particles of the pyrophorus are capable of being kindled by it. He founds his opinion upon various experiments of Dr. Prieſtley, who, with nitrous acid, obtained from ſeveral ſubſtances very pure vital air; as likewiſe on having been able to ſet fire, by means of nitrous acid a pyrophorus that had not been ſufficiently calcined. All pyrophori are, according to this theory, nothing but perfectly dry alkalis combined with phlogiſtic matter, which, in conſequence of the attraction of the air, emit this phlogiſtic matter, when this laſt immediately ſeizes the nitrous acid exiſting in the air, and forms a nitrous ſulphur, that is very eaſily decompoſed, and is kindled in conſequence of the heat produced by the combination.

Scheele gives the following explication of the accenſion of pyrophori. The liver of ſulphur, of which, together with charcoal, this preparation conſiſts, attracts the phlogiſton that has been extracted from the charcoal during the calcination. This ſubſtance, which is compoſed of alkali, phlogiſton and ſulphur, will not take fire without moiſture and dephlogiſticated air. The alkali, which attracts the moiſture ſtrongly, is rendered incapable by it of retaining the phlogiſton any longer, eſpecially as empyreal or dephlogiſticated air is preſent, a ſubſtance which attracts the phlogiſton more powerfully. Now, in conſequence of the empyreal air combining with the looſely adhering phlogiſton, a quantity of heat is generated, which, together with the freſh acceſſion of empyreal air, kindles the ſulphur and charcoal, and afterwards calcines them.

M. Pilatre de Rozier aſſerts, that a certain quantity of phoſphorus exiſts in the pyrophorus, and is the cauſe of its inflammation: for he ſuppoſed the acid of all mucilaginous ſubſtances to be the phoſphoric acid. This philoſopher obtained from fifty-four grains of flowers of ſulphur, thirty-ſix grains of charcoal made of willow, and three grains of phoſphorus, a kind of pyrophorus which took fire in conſequence of being breathed upon, and which, on the addition of twenty-four grains of alkali, emitted a ſulphureous ſmell, ſimilar to that of the aluminous pyrophorus.

Inſtead of entering into tedious diſquiſitions for the purpoſe of examining and confuting theſe ſeveral opinions, Dr. Hopſon's friend adduces that of M. Leonhardi, which appears to him to be the moſt ſatisfactory of any hitherto offered to the public. "As (ſays this author), beſides the aluminous, there are other kinds of pyrophori, in which neither phoſphorus nor ſulphur, nor liver of ſulphur, can be ſuppoſed to exiſt, we muſt ſeek for ſuch an explanation as ſhall be equally adapted to them all. And this appears to me to be found in the inflammable air which is kindled by the heat in conſequence of the acceſſion of the reſpirable air to it." This theory he attempts to eſtabliſh by the following arguments: "A quantity of inflammable air is actually produced in the preparation of the aluminous pyrophorus from burned alum, and a charred vegetable or animal ſubſtance.

I. "For if this mixture be calcined in Bewley's method, viz. covered up with ſand in a tobacco-pipe, a ſort of effervefcent motion may be obſerved in the ſand, which ſeems to ariſe from ſome kind of air that is extricated from it.

II. "If the pyrophorus be prepared, as it uſually is, in an open phial, into which conſequently the external air can enter, a flame is produced, which is nothing but an inflammable air, generated by the vitriolic acid that is detached from the alum, and, on occaſion of the maſs being heated, acts upon the coal, and (on the acceſſion of the external air) is kindled by the heat ſubſiſting near the mouth of the phial. This flame is likewiſe the mark of the operation being nearly finiſhed. If the pyrophorus be calcined till it yields no flame at all, it will never be good, becauſe all the inflammable air is expelled. If the calcination be diſcontinued before the flame becomes weak, it will be but an imperfect pyrophorus; becauſe the alkali contained in it is not dry enough to attract the moiſture in the air, ſo as to generate a ſufficient degree of heat. If, on the other hand, the proceſs be diſcontinued at the time that the flame begins to get weaker, a part of the inflammable air remains in the phial upon the coaly powder, and is abſorbed by it, if the evaporation of it be prevented as uſual. For it is proved by the Abbé Fontana's experiments, that coals abſorb all kinds of air, and conſequently inflammable air. But this inflammable air being but very looſely combined, a very low degree of heat will be able to kindle, not only the inflammable air itſelf, but likewiſe, by means of it, the coal and ſulphur of the pyrophorus; whether the heat, as in Bewley's experiments, be occaſioned ab extra, by actual fire placed at ſome diſtance, or, as Bewley likewiſe experienced, by pouring upon the pyrophorus a drop of the concentrated nitrous acid (which according to Scheele's experiments cannot decompoſe the inflammable air), or, laſtly (as takes place on the expoſure of it to the air), in conſequence of the moiſture of this latter being attracted by the alkali."

The inflammable air contained in the aluminous pyrophorus ſeems to be of the nature of hepatic air, as an odour ſimilar to that of this air is obſerved to ariſe during the burning of the pyrophorus. The pyrophorus, when kept in a looſe, careleſs manner, loſes the property of kindling in the air, becauſe the moiſture which it has ſlowly and gradually attracted from the air prevents its incaleſcence in the air, and perhaps becauſe the inflammable air in part evaporates. But a repeated calcination will reſtore to it this property; becauſe it renders the alkali extremely dry, and makes it able to generate heat again by attracting the moiſture of the air, and probably alſo there is a freſh extrication of inflammable air.

The ſame explication will hold good with reſpect to every kind of pyrophorus made of charcoal, alkali, and calcined vitriols, or vitriolic neutral ſalts, and even to Mr. Bewley's pyrophorus, which conſiſts of alkali and charcoal. This is confirmed by an experiment of Scheele, in which, by diſtilling cauſtic alkali and charcoal together, a quantity of inflammable air was obtained, free from fixed air.

Beſides this, other compoſitions, which, in like manner, take fire on expoſure to the open air, have been by degrees made known to us: 1. The ſcoria of the martial regulus of antimony, as well crude as alſo after being diſſolved, have been obſerved to take fire ſpontaneouſly, when laid upon a hot ſtone, or in the ſun. Of the truth of the latter caſe, Wiegleb ſays he is aſſured by his own experience. 2. Some aſſert that they have obſerved an inflammation enſue from honey and flour calcined according to the rules laid down above. 3. According to Geoffroy, a calcined maſs of three parts of black ſoap, and one of diaphoretic antimony has been known to take fire ſpontaneouſly. 4. Meuder has obſerved, that a pyrophorus is obtained when equal parts of orpiment and iron filings are ſublimed together, and ten parts of this ſublimate are triturated in a mortar along with twelve of nitre of ſilver. 5. A pyrophorus is produced, according to Penzky, when two drachms of white ſand, three of common ſalt, one of ſulphur, two of oil of vitriol, and half an ounce of ſpirit of ſalt, are mixed together and diſtilled in a glaſs retort. In this operation a ſublimate is ſaid to be obtained, which burſts out in flames, as ſoon as it comes into contact with the air. 6. The ſpontaneous precipitate of oſtiocolla, from a ſolution of it in vitriolic acid, after having been ſeparated by means of a filter, and dried, took fire in a warm place. 7. Pott obſerved the ſame phenomenon in the earth of the reſiduum after the diſtillation of urine, that had been putrid for a conſiderable time. 8. To theſe may alſo be referred a maſs compoſed of equal parts of ſulphur and iron filings; which, when thoroughly moiſtened with water, after ſome time grows hot, ſwells, and at laſt breaks out into vapour, ſmoke, and flame. It is difficult to aſcertain the cauſe of theſe and ſeveral other ſimilar experiments, becauſe the circumſtances attending them are complicated, and perhaps not minutely enough related. We learn however by this, that other fixed bodies beſides may have the ſame effect, as, in the uſual mode of preparing pyrophorus, appears to be produced by the earth of alum.

Thoſe pyrophori that require a heat greater than that of the uſual temperature of the atmoſphere for their accenſion, may be termed imperfect pyrophori. They may be compared to the imperfect phoſphori, and are in fact intermediate ſubſtances between the true pyrophori and ordinary combuſtible bodies. Moſt of the following taken by Dr. Hopſon from Mr. Bucholz's paper, in vol. i. of the Chemical Annals, are of a different nature, and appear to be the reſult of fermentation, or the decompoſition of water.

With a view to the prevention of fires, in many inſtances it may be uſeful to make mention, in this place, of certain ſubſtances which, when made warm to a certain degree, or merely mixed with oils, take fire and are deſtroyed. On occaſion of a frigate that in 1781 took fire in the port of Cronſtadt, juſt as ſhe was preparing to ſet ſail, though no fire had been made in her for five days before, M. Georgi, of the Imperial Academy of Peterſburgh, made a great number of experiments, from which we ſhall ſelect the moſt remarkable. He impregnated gradually three pounds of Ruſſian lamp-black with five pounds of boiled hempſeed oil, and, after having left the mixture expoſed to the air for about five hours, wrapped it up in a coarſe linen cloth. This maſs, after having lain in a cheſt for about ſixteen hours, yielded a very offenſive and ſeemingly putrid ſmell, not much unlike that of boiling oil. Some parts of the maſs grew warm, then hot, and emitted a conſiderable quantity of vapour. Theſe vapours were watery, and by no means inflammable. Within about eighteen hours after the packet was made, ſome part of it growing warm exhibited ſmoke, and immediately afterwards was actually ignited. The ſame happened at two or three other places; but others were ſcarcely warm. The fire ſpread very ſlowly, and emitted a thick ſtinking ſmoke. M. Georgi then taking the maſs out of the cheſt, and laying it on a ſtone floor, where it was more expoſed to the air, a flame about ſix inches high aroſe with much ſmoke: whenever any openings or crevices were made in the maſs, they threw out vapours, which ſoon after took fire. The maſs being thrown upon the floor, broke in pieces, and a briſk flame aroſe on a ſudden about three feet in height, which ſoon ceaſed, when the materials continued to glimmer, at firſt with ſmoke, and afterwards without, for the ſpace of ſix hours. The whole was conſumed in about eight hours. The aſhes, which were gray, weighed, when cold, five ounces and a half.

In another experiment, exactly ſimilar to this as to what relates to the mixture and quantity of the materials, the inflammation did not take place for forty-one hours after the oil had been imbibed by the lamp-black. In general the inflammation took place much ſooner in fine clear days than in rainy weather.

In another experiment he impregnated three pounds of Ruſſian lamp-black with three pounds of hemp-ſeed oil unboiled, and the inflammation took place in the ſpace of nine hours. Twelve ounces of fine German lamp-black mixed with twenty-four ounces of boiled hemp-ſeed oil, did not grow warm till after ſeventy hours were elapſed; it then became gradually hotter, and emitted vapours which were not inflammable. The re-action of the materials laſted about thirty-ſix hours, in which time the heat was ſometimes greater and ſometimes leſs, till at laſt it ceaſed entirely. He made a great many more experiments for the Board of Admiralty at Peterſburgh; of which the reſults are theſe. The inflammation takes place much ſooner when Ruſſian lamp-black, which is coarſe, greaſy, and heavy, is impregnated with the oil, than when the German lamp-black, which is light and fine, or common wood ſoot, is employed for this purpoſe. With regard to the oils, the inflammation only happens with drying oils, either boiled or crude. The proportion of the lamp-black to the oil differed greatly in theſe experiments; the lamp-black or ſoot took fire with $\frac{1}{10}$ $\frac{1}{5}$ $\frac{1}{3}$ $\frac{1}{2}$ equal parts, and even with twice the quantity of the oil. In general the inflammation depended more upon the mode of mixing the ingredients than upon the quantity of them; and alſo, as M. Georgi often obſerved, upon the weather; for in wet weather, the maſs, after growing warm, became cold again. A pacquet of hemp, of about thirty pounds weight, was impregnated with a mixture of three pounds of tallow and three pounds of hemp-ſeed oil, and put into a baker's oven, which was heated to 90 degrees of Fahrenheit; on taking it out of the oven, an hour afterwards, it was hardly warm. In the ſpace of an hour after this it began to ſmoke, and in another hour the ſpontaneous inflammation took place; when M. Georgi obſerved that it began about the ſurface, and not in the middle of the maſs. He attributed much to the dry wind that blew on that day. The pacquet burnt for the ſpace of five hours with a viſible flame.

Subſequent to theſe experiments with hemp and flax, this ingenious philoſopher made others with wool: he impregnated twenty pounds of wool with a mixture of two pounds of hemp-ſeed oil, and one of tallow; after having mixed the wool equally with oil, he put it into a ſmall baker's oven, and kept it there for the ſpace of an hour, after which he took it out, and ſewed it up in a mat. The pacquet cooled by degrees, and remained in that ſtate three days, at the expiration of which period the wool was found quite ſound and entire, and the fat was ſo thoroughly imbibed by the wool that it was ſcarcely perceptible. On the ſame wool he now poured a pound of hemp-ſeed oil, and put it again into a baker's oven, of which the heat was 95° of De l'Iſle's thermometer. After remaining there an hour, it was tied up in a coarſe linen cloth, and laid on ſome wood in the laboratory. A few hours after, the pacquet grew warm in ſome places, and emitted a ſlight ſmoke, which increaſed to that degree that two hours afterwards a ſpontaneous inflammation took place. The fire glimmered ſlowly, but when the window was opened it burned for half an hour with a low flame; in the ſpace of forty-four hours it ceaſed burning, when there remained two pounds and ſix ounces of coal, and two pounds of very fine aſhes.

He made a great many experiments beſides, in which the ſpontaneous inflammation took place, ſuch as ſteeping cow-hair and wool in oil, and then expoſing them to a certain degree of heat, &c. from which may be drawn this general concluſion,

cluſion, viz. that oils mixed either with vegetable or with animal ſubſtances, after they have parted with all their water, begin to take fire. The heat may either have been occaſioned by an inteſtine motion, as is the caſe when oils are mixed with coarſe lamp-black, or with black wad, where, by the internal heat, the whole of the fluid previouſly evaporates, the inflammation not taking place till the water is evaporated; or elſe, when vegetable or animal ſubſtances are impregnated with oils, when the oil in conſequence of the great ſurface given it parts with its water ſo much the ſooner, and thus acquires a ſolid and ſubſtantial body, with which it can take fire. This inflammation takes place, as Meſſrs. Hagemann and Geller have obſerved, in Crell's Chemical Annals, 1784, p. 488, in the apothecaries ſhops, in oils that are boiled till they are deprived of all their water.

M. Georgi alſo roaſted barley-groats and rice, and he found that the larger the grains are, the leſs they are diſpoſed to take fire: thus coffee roaſted brown and bound up in linen did not kindle; the contrary to which however was the caſe with ground coffee, which took fire in three quarters of an hour, and continued ſpreading till half an ounce of aſhes remained out of two pounds of coffee. In order to ſatisfy himſelf that it was only the ſize of the coffee-berries that prevented the mutual action of the component parts, the above-mentioned coffee was ground and roaſted again tolerably brown, and wrapped up in linen. In an hour after this, the powder took fire. Saw-duſt of mahogany-wood was roaſted over a gentle fire till it was of a browniſh hue, and kindled in a quarter of an hour after it had been wrapped up.

Two pounds of ſaw-duſt of fir-wood, on account of the different ſize of the particles, became partly black in roaſting, and partly white. After being wrapped up, it ſoon loſt its heat; but, an hour after, the heat returned with ſmoke, when it quickly took fire.

In order to know whether the compreſſion of vegetable ſubſtances, and the modification of the air by ſurrounding them with linen, were eſſential to the ſpontaneous inflammation, and whether a ſpontaneous inflammation would take place without the obſervance of this circumſtance, M. Georgi roaſted ſome barley-coffee till it was brown, which he put into a ſhallow pot, without covering the latter entirely with its lid. After fourteen hours were elapſed, the warmth of the pot returned, and a ſmoke aroſe. There was no fire perceived in the dark; the inſide of the pot however had a phoſphoric appearance, and paper and bits of wood ſoon took fire, and a knife, upon being plunged into the maſs, became red-hot. In twenty-four hours the fire was extinguiſhed.

The following remark of M. Georgi is of the greateſt importance: in the drying of malt, and in roaſting of other ſubſtances of a ſimilar nature, the malt or other materials may take fire of themſelves, in a corner of the kiln, a long time after the operation is finiſhed, and that even in the open air; and, without giving any ſigns of accenſion, except a trifling degree of ſmoke, burn for a conſiderable time, and do a great deal of miſchief.—From all that has been mentioned, it appears that the ſmaller kinds of grain, as well as flour, ſaw-duſt, and other minutely divided and inflammable ſubſtances, when taken in conſiderable quantities, and united with oily matters, are capable of taking fire themſelves under certain circumſtances, in conſequence of their being ſurcharged with inflammable particles, as well as of an inteſtine motion and mutual action in their conſtituent parts, by which the inflammable particles are diſengaged. This is certainly a very remarkable, and hitherto not ſufficiently inveſtigated property of many ſubſtances appertaining to the vegetable and animal kingdoms, the knowledge of which is very important for the farmer, the manufacturer, and artiſt.

PYROTECHNICKS. The art of making fire-works. In this art the chief objects are to produce a ſtream of fire, or an exploſion. Gun-powder included in a ſtrong paper implement affords the latter effect; the latter is produced by mixing the ingredients of gun-powder together in different proportions, and pulverizing them without wetting. Theſe burn more ſlowly than grained gun-powder itſelf. A rocket is formed by ramming this compoſition into a paper tube, to which an arrow or tail is connected. The exploſive ſtream gives the rocket a progreſſive motion by its re-action. Rockets are ſometimes uſed in war; but as they are moſt commonly exhibited for mere amuſement, it is uſual to include gun-powder in the head of the rocket with balls of a ſtill more ſlowly burning compound, with additions to vary the colour they exhibit at the inſtant of exploſion, and for a few ſeconds afterwards.

Lights are alſo made for ſignals and ſtation marks. But as all theſe objects are in ſome meaſure remote from the explanation of ſcientific chemiſtry, the reader is referred to treatiſes written expreſsly on this art. See Rocket.

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QUADRUM, a grit ſtone with a calcareous cement. When it contains about 50 per cent. or more of ſilex, it belongs to this ſpecies; it contains alſo a ſmall proportion of argill and iron; it hardens by expoſure to the air, and then ſtrikes fire with ſteel, and effervefces ſlightly with acids: it is ſometimes cryſtallized in rhomboids, as at Fontainbleau. One hundred parts of this contain, by the experiments of Mr. Laſſone, 62,5 of ſilex, and 37,5 of mild calcareous earth.

The ſaxum margariticum of Linnæus belongs alſo to this ſpecies: it conſiſts of quartz in a calcareous cement.

QUARTATION, is an operation by which the quantity of one thing is made equal to a fourth part of the quantity of another thing. Thus when gold allayed with ſilver is to be parted, we are obliged to facilitate the action of the aqua-fortis by reducing the quantity of the former of theſe metals to one-fourth part of the whole maſs; which is done by ſufficiently increaſing the quantity of the ſilver, if it be neceſſary. This operation is called quartation, and is preparatory to the parting; and even many authors extend this name to the operation of parting. See Parting.

QUARTZ. Some chemiſts make a diſtinction between quartz and rock-cryſtal. Cronſtedt arranges the latter as a ſpecies of the former, as does Kirwan alſo.

In general, thoſe cryſtals of the ſiliceous order which are clear and perfect and do not crack in the fire, are called rock cryſtals. See CRYSTAL, ROCK. And thoſe which are coloured, full of flaws, rounded and irregular, are called quartz.

The tranſparent quartz or rock-cryſtal is either colourleſs and cryſtallized in hexagonal pyramids, and then called mountain cryſtal, or in various other forms, or irregular. Its ſpecific gravity is from 2,65 to 2,7; its texture is lamellar and generally ſhattery, and its appearance is glaſſy. It cracks and loſes its tranſparency when heated; it poſſeſſes all the other properties of pure ſiliceous earth. Bergman has extracted from 100 parts of mountain cryſtal, about 6 of argillaceous, and 1 of calcareous earth. So alſo has Mr. Abilgaard, quoted by Kirwan. Yet Gerhard ſays, that ſome are ſo pure as to contain neither. He alſo ſays, that the irregular cryſtals, though colourleſs, being long digeſted in acids, afforded, when treated with pure Pruſſian alkali, ſome traces of iron.

The pureſt and moſt tranſparent of theſe cryſtals form the falſe diamond, called Briſtol, or kerry-ſtone, diamant d'Alençon, &c.

The coloured tranſparent cryſtals derive their tinge generally from metallic particles in exceeding ſmall proportion; they all loſe their colour when heated; theſe form the falſe gems. The moſt remarkable are the

Red, from Oran in Barbary; falſe rubies.
Yellow, from Bohemia; falſe topazes.
Green; falſe emeralds and praſes.
Violet, }
Blue, } from Bohemia and Saxony.

It is ſaid that brown cryſtals may be cleared by boiling them in tallow.

The opake quartz or pebbles are alſo cryſtallized, or irregularly figured, either white, gray, or yellowiſh, or tinged of other colours by metallic particles. The former are leſs pure than thoſe of the firſt ſeries, containing a larger proportion of clay, or at leaſt the clay is leſs perfectly united with the ſiliceous part. Their ſpecific gravity is from 2,4 to 2,7; their ſurface either rough, or ſmooth and ſhining, the laſt are called fat quartz: the texture either lamellar or granular; they crack like the former in fire, and become of a duller colour; when rubbed againſt each other, they emit a phoſphoric ſmell. They are often found in round maſſes in the beds of rivers.

The coloured opake quartz are either, 1. Black, being mixed with a large proportion of iron. 2. Red. According to Cronſtedt they contain copper, but Bergman could find none in them. 3. Blue, from Uto in Sweden. And 4. Green, found at Adelſdorf in Sweden.

Though the powdery ſtate of other ſtones does not deſerve any particular notice, yet that of quartz or ſilex does, from the great uſe that is made of it, and from its ſeeming to poſſeſs properties which are incompatible with it in a groſſer ſtate. It is of various colours, and incapable of forming a maſs, or hardening with water. The pureſt is white, the minute particles of which, when inſpected through a lens, are tranſparent. It is ſeldom perfectly pure. Mr. Achard ſays, that the fine white ſand of Freyenwald, which is uſed for the porcelain manufactories, contains $\frac{1}{3}$ of its weight of clay and calcareous earth; but Kirwan is inclined to ſuppoſe, that this is a petro-ſilex in powder.

QUARTZ, RHOMBIC. See FELT SPAR.

QUERCITRON. Dr. Bancroft has made known the uſe of the bark of a kind of oak, called yellow oak in New England, and has obtained an excluſive right to the traffick of this bark in France and England: he calls it quercitron.

According to Dr. Bancroft, the quercitron bark may be advantageouſly ſubſtituted for weld in the printing of linens, but it muſt be only ſimply infuſed in warm water, and only one part employed, inſtead of ten of weld.

To dye wool yellow, Dr. Bancroft adviſes that ſolution of tin and alum ſhould be put into the bath with the quercitron. Silk ought to be treated in the ſame manner as with weld: if a very bright yellow is required, it muſt be prepared with ſolution of tin.

It appears from ſome information for which Berthollet was indebted to Mr. Brown, that many manufacturers of printed linens in England at preſent, prefer this bark to weld, becauſe it is conſiderably cheaper, and the ground whitens more eaſily. Some find it advantageous to mix a certain proportion of decoction of weld with the quercitron bath, which ſhould be expoſed to only a gentle heat. M. D'Ambourney aſſerts, that, to obtain the advantages ſet forth by Dr. Bancroft, the wool muſt be firſt prepared with ſolution of tin, and then his proceſs followed.

QUICK-LIME. There is in nature a kind of earths and ſtones, which is ſuſceptible of being changed by the action of fire into the ſubſtance called quick-lime, or calx viva; whence thoſe earths and ſtones are called calcareous, or calcinable. This kind of earth appears to have derived its origin from vegetables and animals, but eſpecially from teſtaceous animals. It is an earth very much attenuated by the action of organiſed bodies, and at the ſame time combined with a certain quantity of water and gas, which make with it an earthy compound of a peculiar nature.

The method of converting earths and ſtones into quick-lime is very ſimple. It conſiſts in expoſing them to the action of fire, till they become of a whitered heat, and in keeping them in this degree of heat during twelve or fifteen hours. Good quick-lime may alſo be made with a leſs heat longer continued, or in leſs time with a more intenſe heat; but care muſt be taken that the heat is not ſufficiently violent to vitrify the calcareous ſtone.

We may know when the calcination is finiſhed by the following ſigns, which at the ſame time ſhew the properties that diſtinguiſh quick-lime from uncalcined calcareous earths; and if the calcination is perfect, theſe properties will be found through the whole ſubſtance of the calcined matter.

We may obſerve that, by calcination, the weight of the ſtones is reduced to about one half, and that they are rendered more friable.

If the calcined ſtones be left expoſed to the air, they gradually crack and crumble into a fine white powder, called lime ſlaked in the air. The quick-lime, while it crumbles thus, recovers great part of its original weight before calcination, and, as its parts do not cohere, its bulk is conſiderably greater than that of the uncalcined ſtone.

If, while the quick-lime is newly made and very ſtrong, it be put into the water, inſtead of expoſing it to air, it preſently cracks and ſplits with noiſe: from the crevices thus formed a hot watery vapour exhales, and in a very little time the whole quantity of quick-lime crumbles, and is reduced to as fine a powder as if it had been a long time expoſed to the air. All theſe effects are accompanied with a great heat. When in this experiment a ſmall quantity only of water is uſed, that is, when no more than the quantity neceſſary to ſlake the lime is added, but not enough to dilute it, it becomes a white impalpable powder like that of the lime ſlaked in the air. But when a larger quantity of it is employed, a white paſte reſults from it, which, although very fine, and cohering in a certain degree, has not the ductility of clay. Water poured copiouſly on this paſte before it dries, eaſily dilutes it, and the fine particles of the lime may be kept ſuſpended by agitation, and give a milky white appearance to the water. But this earthy powder is ſoon depoſited to the bottom of the veſſel in form of a white ſediment, and the water above it becomes quite clear. This water, called lime-water, has a very diſtinct alkaline taſte, and which is even acrid. Upon the ſurface of the water a fine earthy pellicle is gradually formed, called cream of lime. When the pellicle is removed, another will be formed in its place, and thus ſucceſſively till all the lime which had been diſſolved in the water is thus ſeparated.

Accordingly as the earth thus ſeparates from lime-water, this liquor loſes gradually its alkaline taſte, and laſtly becomes quite inſipid. On the other ſide, the cream of lime, which cannot be again diſſolved in water, when well waſhed, has not any alkaline or acrid taſte. This decompoſition of lime-water does not take place when it is kept in full and well cloſed bottles.

Calcareous earth, or crude lime-ſtone, before its calcination, preſents none of theſe phenomena, with air, or with water. It is nearly inſipid, and water diſſolves ſcarcely any of it according to Baumé, and none at all according to Lavoiſier.

All the acids are capable of diſſolving quick-lime, and this ſolution is accompanied with conſiderable heat, but without efferveſcence, or with very little, when the quick-lime is well made. They form with this earth neutral ſalts, entirely ſimilar to thoſe made with uncalcined calcareous earths: but when the acids unite with theſe uncalcined earths, they produce a violent effervefcence, which they do not, as has been already remarked, with quick-lime.

Lime-water not decompoſed, which is nothing elſe than water ſaturated with quick-lime, produces the ſame appearances with acids and other ſubſtances as the quick-lime itſelf, excepting that its combination with theſe ſubſtances is not accompanied with ſo much heat.

Quick-lime and its ſolution, that is, lime-water, have not only the taſte of acrimony, but likewiſe the other properties of fixed alkalis; ſome of which properties, however, are not ſo ſtrongly marked in quick-lime as in the alkalis. Thus quick-lime changes the blue colour of flowers to a green, precipitates all metallic ſolutions, and even ſome ſalts with earthy baſes, ſuch as alum, and decompoſes ammoniacal ſalts, from which it diſengages the volatile alkali. It has ſome action upon oils, ſpirit of wine, and eſpecially upon ſulphur, which it reduces to an hepar, nearly in the ſame manner as alkalis do. Theſe alkaline ſaline properties diſtinguiſh quick-lime from uncalcined calcareous earths, which, however, in a very ſmall degree, poſſeſs ſome of the ſame properties.

Fixed and volatile alkalis, treated with quick-lime, become fluor, deliqueſcent, incapable of effervefcing, cauſtic, and capable of acting like ſolvents on many bodies, eſpecially thoſe of an oily nature, with much more force and activity than in their ordinary ſtate; and the quick-lime, by thus communicating cauſticity to alkalis, loſes its own cauſticity, and acquires all the properties of uncalcined calcareous earth.

Quicklime which has been flaked in water, and not long expoſed to air, preſerves its cauſticity, at leaſt in a great meaſure, and the property of rendering alkalis cauſtic, deliqueſcent, and incapable of effervefcing.

If to lime-water be added, alkalis that are effervefcing and not cauſtic, or the gas which eſcapes from the effervefcence of theſe alkalis or uncalcined calcareous earth, or the gas of the vinous fermentation; or laſtly, if lime-water be mixed with air that has been reſpired, or in which any combuſtion has taken place; this lime-water will be rendered turbid, will be immediately decompoſed, the lime will ſeparate from it, and precipitate in the ſtate of an unſoluble calcareous earth, deprived of all cauſticity, effervefcing with acids, and perfectly like uncalcined calcareous earths: and it is well worth remarking, that cauſtic alkalis, whether fixed or volatile, do not precipitate lime-water; but that this water may be precipitated by adding ſpirit of wine, which ſpirit not containing any gas, the precipitate produced by its means from lime-water is not in the ſtate of uncalcined calcareous earth, but in the ſtate of quick-lime.

The earthy precipitate obtained from lime-water by effervefcing alkalis, or by the ſeveral kinds of gas above mentioned, may again recover its cauſticity, its ſolubility, and all the other properties of quick-lime, by two methods: 1. By expoſing it to fire, in the ſame manner as calcareous ſtones are converted into quick-lime; and by this calcination it loſes the ſame proportion of water and of gas as theſe ſtones do: 2. By diſſolving it in an acid, and precipitating it from the ſolution by adding a cauſtic non-effervefcing alkali; and in this manner alſo crude calcareous earths may be converted into quick-lime.

By ſubjecting calcareous ſtones to calcination in an apparatus of cloſe veſſels, ſo that whatever is expelled by fire may be obtained, Meſſrs. Hales, Jacquin and others, and moſt perſpicuouſly Dr. Black, have ſhewn, 1. That theſe ſtones may be converted into quick-lime without the concurrence of the external air, contrary to the opinion of Van Helmont and of Daniel Ludovic, who had affirmed the contrary, and who conſidered the calcination of quick-lime as the combuſtion of an inflammable matter, with which they believed the ſaline parts of calcareous earths were enveloped. 2. It has been alſo ſhewn that, during this calcination in cloſe veſſels, a certain quantity of aqueous liquor is expelled from calcareous ſtones, even although they had been previouſly well dried. 3. Laſtly, it is found, that a conſiderable quantity of permanently elaſtic fluid is diſengaged during the calcination, and that this vapour is the ſame as the gas, which is expelled by adding acids to calcareous earth, and which occaſions the effervefcence that ariſes upon miſſing theſe ſubſtances. See AIR, FIXED.

Quick-lime is of great uſe in building, as it is the principal ingredient in mortar, which is a mixture of quick-lime ſlaked with water, and a certain quantity of ſand, or of pounded burnt clay. This mixture, when it dries, has the property of becoming ſolid and hard to a conſiderable degree, which renders it fit to be uſed as a cement to bind together the ſtones of a building.

The cauſe of the induration of mortar may be naturally deduced from the properties of quick-lime, and eſpecially from the great fineneſs of its parts when it is ſlaked. The extreme diviſion of the parts of this ſtone, which are thus reduced almoſt entirely to the ſurface, gives them an opportunity of applying themſelves immediately upon the ſurface of the hard parts of the ſand, or burnt clay, and of adhering with a force proportionable to the intimacy of contact.

We cannot doubt that the water, which neceſſarily enters into the compoſition of the mortar, contributes alſo much to its hardneſs. For if we diſtil the oldeſt, hardeſt and drieſt mortar with a heat nearly equal to that uſed in the calcination of lime-ſtone, a good deal of water is obtained from it, and it loſes at the ſame time its conſiſtence and hardneſs. We ſee every day in laboratories an example of what happens to mortar. When lime-water has remained during ſome time in open veſſels, the earth of the lime forms an incruſtation on the ſides of the veſſels; and this incruſted matter adheres ſo ſtrongly to the ſides of the veſſel, that it cannot be diſengaged by rubbing, without at the ſame time wearing off part of the ſurface of the veſſel.

It may be aſked, why the dried paſte of quick-lime, without addition of ſand or burnt clay, does not acquire the conſiſtence and hardneſs of the mortar, as is well known? This difference proceeds in general from hence, that the parts of the quick-lime can apply themſelves ſooner to thoſe of hard bodies than they can to each other; but it alſo appears probable that water contributes greatly to this effect. The phenomena of the extinction of quick-lime in water, and the difficulty aſcertained by M. Duhamel's experiments (Mem. de l' Acad. 1747) of depriving quick-lime, by means of fire, of all the water it had abſorbed during its extinction, demonſtrate, that quick-lime contracts a very ſtrong adheſion to water.

The properties of the mortar ſhew of how much conſequence perfect drying is to the goodneſs of this compound. After many reſearches into the means of increaſing the ſolidity and hardneſs of mortar, M. Loriot found, that this effect could be produced by adding to mortar a certain quantity of quick-lime. We cannot doubt that the ſuperiority of this new mortar, over that made in the old way with ſlaked quick-lime, proceeds from this cauſe; that the added quick-lime diminiſhes, as far as is uſeful, the proportion of the water remaining in the mortar.

Mr. Loriot's mortar is made in the following manner. Take one part of very fine brick-duſt well ſifted, two parts of fine river ſand well ſcreened, and a ſufficient quantity of ſlaked lime, to form a mortar which muſt be ſo wet that it can ſlake a quantity of quick-lime in powder, equal to one fourth of the brick duſt and ſand taken together: then add this quick-lime in powder to the brick-duſt and ſand, incorporate them well with the wet mortar, and uſe the mixture directly, as the ſmalleſt delay may render the uſe of it defective or impoſſible.

QUICKSILVER. In addition to what has been ſaid on mercury, and the ores of mercury, I ſhall here add the commercial ſtate of that article, as I find it in Mr. Raſpe's Addreſs to the Subſcribers of Baron Rork's Work on the Amalgamation of Gold and Silver Ores.

Of the Spaniſh quickſilver mines in America he obſerves that he has little to ſay, except that their produce is more than wholly abſorbed by the gold and ſilver mines in South America; and that Spain, ſo far from having any quickſilver to export, is on the contrary under the neceſſity of buying vaſt quantities to ſupply the American mines, whoſe conſumption of quickſilver muſt have been enormous hitherto, as, by their common proceſs of cold amalgamation, they loſt 15 oz. for each marc of ſilver. It is ſuppoſed to be annually from 17 to 24,000 quintals (Ferb. l. 1. p. 82); and as Spain has but lately contracted with the Board of Mining at Vienna for an annual ſupply of 10,000 quintals of quickſilver from Idria during the courſe of ten years to come, one may nearly calculate the quickſilver produce of the Spaniſh mines in America and at Almaden. Whatever it be, the ſucceſs of the proceſs of amalmagation in Europe muſt ultimately depend upon the produce of the quickſilver mines in Europe, which are in Friuli, Tranſylvania, Hungary, Carinthia, Bohemia, the Palatinate, and Zweybruck.

The greateſt and moſt productive of all is that at Idria in Friuli. Formerly its produce was between 2 and 3000 quintals; and though the prime coſt was but from 8 to 12 flor. yet by contract almoſt the whole produce was made over, for intereſt and part of payment of a ſum of money negociated in Holland, to Meſſrs. Goll and Company at Amſterdam, at the rate of 150 flor. allowing that Houſe to ſell

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it at the rate of 200 flor. or 22l. 4s. $5\frac{1}{4}$d. and obliging all the ſubjects of Auſtria to buy it at the ſame price.

When this contract expired, the burthenſome debt of Holland being diſcharged, a lower price, that of 110 flor. was fixed upon for the purpoſe of underſelling the quickſilver mines in the Palatinate and Zweybruck, which cannot raiſe that commodity under 110 flor.; and the more effectually to prevent their concurrency in the market, 1, 3, and 6 quintals were allowed gratis as an encouragement to the buyers of lots of 100, 200, or 300 quintals. But the public was not benefited by this lower price; nor were the Palatine mines materially hurt or ſtopt by it, as intended; for Meſſrs. Verbrug and Goll at Amſterdam, appointed again factors for Idria, took all the quickſilver at that lower price, and raiſed it as much as they pleaſed. Such was the ſtate of the quickſilver trade, when the ſucceſs of amalgamation gave it a new turn, and proved a wonderful encouragement to the quickſilver mines at Idria. The works were puſhed and extended with great ſpirit and exertion, ſo that the annual produce of Idria is now actually 16,000 quintals; but the tarif and regulations adopted by the Board of Mining at Vienna are rather unaccountable. By a ten years contract with the court of Spain, 10,000 quintals are annually ſold to Spain at the rate of 90 flor. or 19l. The Hungarian, Bohemian, and Auſtrian quickmills are ſupplied at the rate of 110 flor. or 12l. 8s. Other Auſtrian ſubjects, or plate-glaſs and cinnabar manufacturers, have their ſupplies at the rate of 150 flor. or 16l. $13\frac{1}{3}$s. ſterl. and the reſt of Europe at the rate of 167 flor. or 18l. 12s. ſterl. From a ſuppoſition that thus the ſale is perfectly ſecured to Idria, and from a ſpirit of monopoly, the Auſtrian Board of Mining gave now full liberty to work and open other private quickſilver mines in the Auſtrian dominions, with an offer to take any quantity of their produce at the rate of 100 flor. or $11\frac{1}{9}$l. ſterl. by way of preemption; which, however, none of theſe mining companies will make uſe of, or agree to, as perfectly ſure of the better medium price of 150 flor. or 16l. $13\frac{1}{2}$s. ſterl. in the general market of Europe, which for the preſent wholly depends upon the unengaged quickſilver of Idria, the produce of theſe private mines, and of thoſe in the Palatinate and Zweybruck.

The unengaged quickſilver of Idria is not annually above 4000 quintals.

That of the mines in the Palatinate and Zweybruck is from 800 to 1000.

That of the private mines in Tranſylvania, and other dominions of the Houſe of Auſtria, for the preſent inconſiderable and uncertain; but there is every reaſon to think that, by more ſpirited exertion, they will become more productive. They are in various places in Tranſylvania; in Upper Hungary, near Roſenaw; in Lower Hungary, between Newſol and Cremniz in the Orthuth mountains, where running quickſilver is found in clay immediately under graſs, above a ſeam of coals, as alſo native cinnabar in quartz; in Carinthia near Neumarktel, and in Bohemia near Shoenfeld, and at Horſhoviz and Swata. (Ferb. l. 1. p. 143.) Whatever their future produce and the future ſucceſs of the mines in the Palatinate and Zweybruck may be, it plainly appears that hitherto Auſtria has wholly regulated the quickſilver price, and to all appearances will regulate it by its very cheap produces at Idria, till theſe mines ſhall be exhauſted, and till Spain and other kingdoms can provide for themſelves. Mr. Raſpe concludes by expreſſing his ſatisfaction in the hope that Great Britain has a chance alſo to have quickſilver mines of her own, nor any longer in that reſpect to be dependent on foreign regulations of finance, ſpeculation, and monopoly.

QUINQUINA. See PERUVIAN BARK.

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RAGG-STONE. The colour of this ſtone is gray; its texture obſcurely laminar, but the laminæ conſiſt of a congeries of grains of a quartz appearance, coarſe and rough; its ſpecific gravity is 2,779; it effervefces with acids, and gives fire with ſteel. It is uſed as a whetſtone, frequently without the application either of water or oil.

Whence it comes to us I know not, but its appearance reſembles the pumice in every reſpect except denſity, in which this greatly exceeds. Its component parts in Kirwan's tables are, 70 ſilex, 5 clay, 25 mild calcareous earth, and 5 iron, as he thinks.

RAIN. See METEORS.

RAINBOW STONE. See MOON-STONE.

RANCIDITY. The change which oils undergo by expoſure to the air.

Fixed oil, expoſed for a certain time to the open air, abſorbs the vital part, and acquires a peculiar odour of fire, an acrid and burnt taſte, at the ſame time that it becomes thick and coloured. If oil be put in contact with vital air in a bottle, it becomes more ſpeedily rancid, and the air is abſorbed. Scheele obſerved the abſorption of a portion of the air before the theory was well aſcertained. Oil is not ſubject to alteration in cloſed veſſels.

It appears, according to the obſervation of Chaptal, that vital air combined with the mucilage, conſtitutes rancidity; and that, when combined with the oil itſelf, it forms drying oil.

The rancidity of oils is therefore an effect analogous to the calcination of metals. It eſſentially depends on the combination of pure air with the extractive principle, which is naturally united with the oily principle. This inference is proved by attending to the proceſſes uſed to counteract or prevent the rancidity of oils.

When olives are prepared for the table, every endeavour is uſed to deprive them of this principle, which determines their fermentation; and for this purpoſe various methods are uſed. In ſome places they are macerated in boiling water charged with ſalt and aromatics; and after twenty-four hours digeſtion, they are ſteeped in clear water, which is renewed till their taſte is perfectly mild. Sometimes nothing more is done than to macerate the olives in cold water; but they are frequently macerated in a lixivium of quick-lime and wood-aſhes, after which they are waſhed in clear water. But in whatever manner the preparation is made, they are preſerved in a pickle charged with ſome aromatic plant, ſuch as coriander and fennel. Some perſons preſerve them whole; others ſplit them, for the more complete extraction of their mucilage, and in order that they may be more perfectly impregnated with the aromatics.

All theſe proceſſes evidently tend to extract the mucilaginous principle, which is ſoluble in water, and by this means to preſerve the fruit from fermentation. When the operation is not well made, the olives ferment and change. Chaptal affirms, that, if the olives be treated with boiling water to extract the mucilage before they are ſubmitted to the preſs, a fine oil will be obtained, without danger of rancidity.

When the oil is made, if it be ſtrongly agitated in water, the mucilaginous principle is diſengaged; and the oil may be afterwards preſerved for a long time without change. The author above mentioned preſerved oil of the marc of olives, prepared in this manner, for ſeveral years in open bottles without any alteration.

The torrefaction to which ſeveral mucilaginous ſeeds are ſubjected before the extraction of the oil, renders them leſs ſuſceptible of change, becauſe the mucilage has been deſtroyed.

M. Sieffert has propoſed to ferment oils with apples or pears, in order to deprive rancid oils of their acrimony. By this means they are cleared of the principle, which had combined with them, but now becomes attached to other bodies.

Mucilage may therefore be conſidered as the principle of the rancid ferment.

RAPAKIVI. See GRANITE.

REALGAR. See ORPIMENT.

RECEIVER. Receivers are chemical veſſels, which are adapted to the necks or beaks of retorts, alembics, and other diſtillatory veſſels, to collect, receive, and contain the products of diſtillations.

Receivers ought to be made of glaſs, not only becauſe this matter reſiſts the action of the ſtrongeſt and moſt corroſive ſubſtances, but alſo becauſe, being tranſparent, it allows the operator to ſee through it, and to judge, by the frequency of the drops, if the diſtillation be too faſt or two ſlow, and alſo if the quantity and nature of the ſubſtances which come over be ſuch as are required.

Almoſt all receivers are a kind of bottles of different ſizes, of a ſpherical form, the necks of which are cut ſhort, and each of which is pierced with a ſmall hole in its lateral or upper part, to give vent to the air or vapours, which are too expanſive. Receivers of this form are called balloons. See BALLOON.

Some receivers are mattraſſes with long necks. Theſe are generally adapted to the beaks of glaſs alembics. This long neck ſerves to keep the belly of the receiver, where the liquor is collected, at a proper diſtance from the fire.

Receivers have different forms for particular operations. Such are thoſe which have too or three beaks, either to be adapted to other receivers, or to admit at the ſame time the necks of ſeveral diſtillatory veſſels, when the intention of the operator is, that the vapours of different ſubſtances ſhould meet in the ſame receiver. Such alſo are receivers for eſſential oils, which are very convenient for the diſtillation of theſe oils. To obtain the eſſential oil of aromatic plants, theſe plants muſt be diſtilled with water. The plant and the water are to be put together into a cucurbit, and the water, which is to receive a boiling heat, riſes in diſtillation, carrying with it the eſſential oil, which alſo has the property of riſing with this degree of heat. See OILS.

As a large quantity of water muſt be employed, that the plant may always be kept immerſed in the alembic, and conſequently as a good deal of it riſes in proportion to the oil, any receiver of ordinary ſize would be ſoon filled with water with a little oil floating upon its ſurface; and would require to be frequently changed, which would be very troubleſome, and would occaſion a loſs of part of the oil.

Theſe inconveniences are avoided by uſing receivers contrived purpoſely for ſuch diſtillations. They are ſo made, that they are never full, but that the water runs out, and leaves the oil behind. They are a kind of glaſs cucurbits, which contract as they riſe higher; ſo that their neck, or upper opening, is but nearly of a convenient ſize to receive the beak of the worm. Theſe receivers have another opening about the middle of the ſwelling or belly; and to this opening is joined a glaſs tube, which bends and riſes vertically along the outer part of the receiver, ſo as to be within two inches and a half as high as the upper opening. At this height the tube bends again towards the ſide oppoſite to the body of the receiver, to pour into another veſſel the liquor which riſes there. It forms the figure of S.

When this receiver is to be uſed, it is to be placed vertically under the beak of the worm. During the diſtillation, the liquor riſes to an equal height in the body of the receiver and in the crooked tube: when therefore the height of the liquor in the receiver becomes greater than the height of the tube, it muſt begin to flow from the mouth of this tube into another veſſel placed on purpoſe to receive it: but as eſſential oils are either lighter or heavier than water, and as they are therefore always collected either above or under the water, and as the liquor which diſcharges itſelf through the tube is taken from the middle part of the receiver, therefore nothing but water can be evacuated at the mouth of the pipe, while the oil always remains in the receiver. Thus, with ſuch a receiver, we may diſtill without the trouble of changing the veſſels; which is certainly very advantageous.

RECTIFICATION. By rectification is meant the exact purification of certain ſubſtances, by means of diſtillation or ſublimation.

This operation is neceſſary to diſengage many chemical products or agents from a mixture of extraneous matters which deſtroy their purity. Thus, for inſtance, vitriolic acid, when firſt obtained from vitriol, or from ſulphur, is always charged with a conſiderable quantity either of inflammable matter, which renders it black and ſulphureous; or of ſuperabundant water, which weakens it. It is ſeparated from both theſe matters by a ſecond diſtillation, in which they being more volatile than the acid, are carried off; which ſecond diſtillation is called concentration or rectification of vitriolic acid. See CONCENTRATION OF VITRIOLIC ACID.

Alſo, when animal and vegetable matters are decompoſed by diſtillation, all the portion of oil that is not volatile, contained in theſe ſubſtances, does not riſe but with a degree of fire ſo ſtrong as to burn a part of them, and to raiſe along with them a conſiderable portion of ſaline ſubſtances, which being mixed with the oily part, conſiderably alter its purity. To purify theſe oils, which from their burnt ſmell are called empyreumatic, new diſtillations muſt be applied, in which, by means of a leſs heat, the moſt volatile and pureſt part of theſe oils is ſeparated from the moſt empyreumatic and ſaline parts, which remain at the bottom of the retort: this is called the rectification of empyreumatic oils. See OIL.

The ardent ſpirits obtained by a firſt diſtillation of liquors which have undergone the ſpirituous fermentation are overcharged with a large quantity of phlegm and light oil, which riſe along with them in this firſt diſtillation. The product of this diſtillation has been called aqua vitæ. It is an ardent ſpirit, very far from the degree of dephlegmation and purity which good ſpirit of wine ought to have to render it fit for chemical operations, and for ſeveral compounds commonly uſed, ſuch as perfumed waters and liqueurs for the table. This ſpirit of wine is to be purified, or rather the aqua vitæ is to be changed into ſpirit of wine by new diſtillations, ſlowly conducted with a gentle fire and water-bath; by means of which the moſt volatile part, that always riſes firſt with the leaſt heat, and which is the true ſpirit of wine, is ſeparated from the leſs volatile part that remains in the alembic, and which contains the phlegm and oil of wine by which the ſpirit of wine was rendered impure. The firſt liquor of theſe ſecond diſtillations or rectifications is called rectified ſpirit of wine. For its properties ſee SPIRIT (ARDENT).

When only a ſmall quantity of ſpirit of wine is to be rectified, the operation is difficult, eſpecially when we would have it perfectly rectified. The cauſe of this difficulty proceeds from the very ſmall quantity of the firſt liquor obtained in this rectification. Several chemiſts, to obtain a larger quantity of the firſt ſpirit, propoſe to mix with the ſpirit of wine ſome intermediate ſubſtances to abſorb and retain its phlegm and oil, ſuch as dried and calcined ſalts, very dry chalk, &c. Kunckel propoſes to ſeparate more effectually the oil, by adding to the ſpirit a large quantity of water, and by diſtilling this diluted ſpirit with a very gentle heat. This method is indeed very capable of facilitating the ſeparation of the oil of wine from the ſpirit of wine; becauſe this oil certainly adheres to the ſpirit, which is the chief obſtacle to its ſeparation; and becauſe the ſpirit of wine has greater affinity with water than with oil; ſo that when it is diluted with much water, it quits the oil to unite with the water. This experiment of Kunckel is therefore very good to facilitate the ſeparation of ſpirit of wine from the oil which renders it impure; but, on the other hand, when it is practiſed, we are afterwards obliged to deprive the ſpirit of wine of the water with which it was diluted.

All this trouble and inconvenience may be avoided by rectifying at once a large quantity of aqua vitæ. Nothing more is required to obtain at once a conſiderable quantity of pure ſpirit of wine, than to ſet aſide the twelve or fifteen pints firſt drawn over from a large quantity, ſuppoſe from three hundred pints of aqua vitæ, diſtilled with a very gentle fire in a large alembic. As the moſt ſpirituous, leaſt aqueous, and leaſt oily part of it always riſes firſt, theſe twelve or fifteen pints are perfectly rectified ſpirit of wine, eſpecially when the heat has been well conducted. By thus keeping apart portions of the ſpirit obtained at different times, we may have ſpirit of wine of the ſeveral degrees of ſtrength and purity. The weaker ſpirit may, by another diſtillation, be again rectified. Laſtly, the ſpirit of moderate ſtrength may be preſerved, as it is fit for many uſes. This method is followed by Mr. Baumé in the rectification of ſpirit of wine, and is certainly the moſt convenient and the beſt.

The volatile ſalts obtained in the decompoſition of certain oily ſubſtances, as volatile alkalis, from decompoſed animal matters, are always very impure, and ſpoiled by much fetid empyreumatic oil, which riſes along with them. They are purified and diſengaged by ſubjecting them to new diſtillations or ſublimations with a well conducted heat. The ſame obſervation is applicable to butter of antimony, artificial cinnabar, phoſphorus, and to many other chemical products, which are always impure when obtained by a firſt operation, and muſt therefore be purified by a ſecond diſtillation or ſublimation. All theſe ſecond operations, intended merely to purify matters, are called rectifications. They are not generally attended with much difficulty. We ſhall not therefore enter into the details of them; but we ſhall only obſerve, that all rectifications are founded upon the ſame principle. They all conſiſt in ſeparating ſubſtances more volatile from ſubſtances leſs volatile; and the general method of effecting this is to apply only the degree of heat which is neceſſary to cauſe this ſeparation. See DISTILLATION and SUBLIMATION.

RED CABBAGE. For the uſe of this as a teſt, ſee Brassica Rubra.

REDDLE, or Red Chalk, a calciform ore of iron commonly uſed as a pigment.

RED LEAD. See Minium.

REDUCTION, or REVIVIFICATION. This word, in its moſt extenſive ſenſe, is applicable to all operations by which any ſubſtance is reſtored to its natural ſtate, or which is conſidered as ſuch: but cuſtom confines it to operations by which metals are reſtored to their metallic ſtate, after they have been deprived of this ſtate, either by the combuſtion of their phlogiſton, as the metallic calces, or by the union of ſome heterogeneous matters which diſguiſe them, as fulminating gold, luna cornea, cinnabar, and other compounds of the ſame kind. Theſe reductions are alſo called revivifications. Macquer has explained both theſe kinds of reduction very perſpicuouſly, as follows:

The reduction of metallic calces regards only imperfect metals; becauſe theſe alone are ſuſceptible of loſing their metallic properties by the loſs of phlogiſton. They may be deprived of this principle by the action of air or of water, which changes them to ruſt; or by the action of acids, particularly of the nitrous and vitriolic; or laſtly, by ordinary calcination, that is, by combuſtion in an open fire.

Metals deprived of their phlogiſton by any of theſe cauſes have not their peculiar colour, luſtre, ductility, nor even conſiſtence and gravity. They have the appearance of earths, the parts of which are unconnected, unleſs they have ſuſtained a fire violent enough to fuſe them; and then they become brittle vitrified matters.

But theſe metallic earths, calces, or glaſſes, are capable of being again reſtored to the combuſtible ſtate, and of recovering all the metallic properties. For this purpoſe their calcination muſt not have been too complete, and ſome other combuſtible matter muſt be applied in a ſtate favourable for combination. Theſe calces, particularly of ſuch metals as cannot be radically calcined, as lead, biſmuth, iron and copper, may recover their combuſtible ſtate, and may be reduced, even without fire or fuſion, merely by the contact of volatile inflammable matter; for inſtance, by hepatic air of liver of ſulphur; or they may be reduced in the humid way, that is, when they are precipitated by ſome proper ſubſtance. See Phosphorus, alſo Precipitate.

But we muſt obſerve, that metals reduced by either of theſe methods are only ſuperficially ſo, when the metallic maſſes are conſiderably large; and that when the metals thus reduced conſiſt of fine molecules, theſe molecules, though well reduced and provided with all their metallic properties, remain always disjoined and ſeparated from each other; either becauſe they are not ſmall enough, or becauſe they have not time to unite and agglutinate together, as they have when they are combined by nature; for metals are certainly formed naturally by theſe methods: but the operations of our laboratories are very different from thoſe of nature. Accordingly, in practical chemiſtry a much more expeditious method for making theſe reductions is employed; which is fuſion.

The reduction of metallic calces by fuſion is generally a quick and eaſy operation. It however requires certain attentions and management; which are: 1. To mix accurately the metallic calx to be reduced with the proper quantity of the combuſtible matter which is to reduce it. 2. To add to the mixture ſome ſaline or vitreous matter capable of facilitating the fuſion and ſeparation of the reduced metal from the ſcoria. 3. To prevent any communication with external air, that the inflammable addition may not be burnt and conſumed. 4. To keep the fire low at firſt, that the too great ſwelling which is generally occaſioned by the extrication of volatile or elaſtic matter, may be prevented; and to raiſe the fire towards the end, ſo that not only the metal, but alſo the ſupernatant ſcoria, may be perfectly fuſed. For if the ſcoria was not well fuſed and tenacious, it would retain much of the reduced metal, and prevent it from falling down to the bottom of the crucible.

The operations muſt be very exactly performed, eſpecially in eſſays of ores, in which the preciſe quantity of metal is required to be known. Theſe eſſays of ores are in ſome meaſure the only reductions of this kind which are performed in practical chemiſtry, as the reduction of pure metallic calces differs only from the former in requiring a leſs quantity of flux; becauſe theſe calces do not, as the ores do, contain a difficultly fuſible earthy or ſtony matter: we therefore refer to the article Ores. Here it may be obſerved, that when we treat very volatile ſemi-metals, as zinc and arſenic, the reduction ought to be made in veſſels perfectly cloſe; for inſtance in an earthen retort. We find theſe metallic matters after the reduction ſublimed in the vault or neck of the retort.

The reduction of metals which do not eaſily loſe their combuſtible ſtate, as gold, ſilver, and mercury, is of another kind. As theſe metals can only be diſguiſed by the union they have contracted with ſome heterogeneous ſubſtance, they are to be reduced ſimply by the addition of ſome intermediate ſubſtance capable of ſeparating from them the matter which is united with them. Theſe intermediate ſubſtances muſt therefore differ according to the matter united with the metal.

For inſtance, fulminating gold may be reduced by fuſing it with ſulphur, or with fixed alkali; becauſe either of theſe ſubſtances is capable of ſeparating the volatile alkali, which gives the fulminating property to gold. See Gold (Fulminating). Luna cornea alſo is reduced by fuſing it with a large quantity, as for inſtance with twice its weight of fixed alkali; becauſe in this reduction the marine acid united with the ſilver is to be ſeparated, and the fixed alkali is capable of effecting that ſeparation. The reduction of luna cornea is attended with difficulties, becauſe this compound is ſemi-volatile and very penetrating; ſo that when it is expoſed to fire, ſome part of it is always loſt, whether it exhales in vapours or penetrates the crucible. Several chemiſts recommend the reduction of luna cornea by fuſing it with fat matters, which, from experience, Macquer declares to be a very bad method; for the marine acid has a ſtrong affinity with ſilver, and has no diſpoſition to unite with phlogiſton, or even with ſubſtances which contain much of it. See Silver.

Luna cornea may alſo be well reduced by precipitation, and by treating it with other metals which have more affinity than ſilver with marine acid, ſuch as tin, iron, regulus of antimony. Margraaf gives, in his Opuſcules Chemiques, a proceſs which deſerves a place here; becauſe, according to this excellent chemiſt, a very pure ſilver is obtained, and without any loſs. It conſiſts in mixing well in a glaſs mortar luna cornea with ſome concrete volatile alkali, in the proportion of above five gros of luna cornea with an ounce and a half of volatile ſalt, to which a little water is to be added to give to the mixture a ſoft conſiſtence. The mixture ſwells with a kind of efferveſcence. After it has been triturated a quarter of an hour, three ounces of very pure mercury revived from cinnabar are to be added. The trituration is to be renewed for two or three hours, and half a gros of volatile alkali is to be added, to replace that which is diſſipated; and afterwards a larger quantity of water. Upon the addition of this water appears a fine amalgam of ſilver, which is to be waſhed ſeveral times, till the water comes off clear. This amalgam is then to be diſtilled; by which the mercury is expelled, and all the ſilver which was contained in the luna cornea remains pure, excepting about four grains which have been waſhed away.

The mercury of cinnabar is to be reduced or ſeparated from ſulphur, by mixing with the cinnabar any ſubſtance which has greater affinity with ſulphur than mercury has; ſuch as fixed alkalis, abſorbent earths, iron, copper, lead, ſilver, or regulus of antimony. Filings of iron are generally employed in this operation, an equal weight of which is to be mixed with the cinnabar, and the whole diſtilled together, by which the mercury will be raiſed and collected at the bottom of the receiver under ſome water placed there to facilitate its condenſation. The ſulphur of the cinnabar remains in the retort united with the intermediate ſubſtance employed for the ſeparation. This mercury is called mercury revived from cinnabar; and is juſtly conſidered as very pure.

REFINING is a term uſed in chemiſtry and ſeveral arts to ſignify the purification of ſome ſubſtance, particularly of metals, as gold, ſilver, copper, iron, &c.

We ſhall here treat only of the refining of gold and ſilver; and for the refining of other ſubſtances we refer to their ſeveral articles.

Gold and ſilver may be refined by ſeveral methods, which are all founded on the eſſential properties of theſe metals, and acquire different names according to their kinds. Thus, for inſtance, gold, having the property which no other metal, not even ſilver, has, of reſiſting the action of ſulphur, of antimony, of nitrous acid, of marine acid, may be purified by theſe agents from all other metallic ſubſtances, and conſequently may be refined. Theſe operations are diſtinguiſhed by proper names, as purification of gold by antimony, parting, concentrated parting, dry parting. In a ſimilar manner, as ſilver has the property, which the imperfect metals have not, of reſiſting the action of nitre, it may be refined by this ſalt: but the term refining is chiefly applied to the purification of gold and ſilver by lead in the cupel. We ſhall therefore treat only of this latter manner of purifying theſe metals, referring for the others to the words PURIFICATION and PARTING, which ſee.

The refining of gold and ſilver by lead in the cupel is performed by the deſtruction, vitrification, and ſcorification of all the extraneous and deſtructible metallic ſubſtances with which they are allayed.

As none but the perfect metals can reſiſt the combined action of air and fire, without burning, that is, without loſing their inflammable principle, according to the ancient theory of combuſtion, or combining with vital air according to the new, and are by that means changed into earthy or vitreous matters incapable of remaining any longer united with ſubſtances in a metallic ſtate; there is then a poſſibility of purifying gold and ſilver from all allay of imperfect metals merely by the action of fire and air; only by keeping them fuſed till all the allay be deſtroyed: but this purification would be very expenſive, from the great conſumption of fuel, and would be exceedingly tedious. Macquer ſays, he has ſeen ſilver allayed with copper, expoſed longer than ſixty hours to a glaſs-houſe fire, without being perfectly refined: the reaſon of which is, that when a ſmall quantity only of imperfect metal remains united with gold or ſilver, it is covered and protected from the action of the air which is neceſſary for the combuſtion of the imperfect metals, as of all combuſtible matters. See CALCINATION.

This refining of gold and ſilver merely by the action of fire, which was the only method anciently known, was very long, difficult, expenſive, and imperfect: but a much ſhorter and more advantageous method has been diſcovered. This method conſiſts in adding to the allayed gold and ſilver a certain quantity of lead, and in expoſing afterwards this mixture to the action of the fire. Lead is one of the metals which loſes moſt quickly and eaſily, enough of its inflammable principle to ceaſe to be in a metallic ſtate; but at the ſame time this metal has the remarkable property of retaining, notwithſtanding the action of the fire, enough of this ſame inflammable principle to be very eaſily melted into a vitrified and powerfully vitrifying matter, called litharge. See LITHARGE.

The lead which is to be added to the gold and ſilver to be refined, or which happens naturally to be mixed with theſe metals, produces in their refining the following advantages: 1. By increaſing the proportion of imperfect metals, it prevents them from being ſo well covered and protected by the perfect metals. 2. By uniting with theſe imperfect metals, it communicates to them a property it has of loſing very eaſily a great part of its inflammable principle. 3. Laſtly, by its vitrifying and fuſing property, which it exerciſes with all its force upon the calcined and naturally refractory parts of the other metals, it facilitates and accelerates the fuſion, the ſcorification, and the ſeparation of theſe metals. Theſe are the advantages procured by lead in the refining of gold and ſilver.

The lead, which in this operation is ſcorified, and ſcorifies along with it the imperfect metals, ſeparates from the metallic maſs, with which it is then incapable of remaining united. It floats upon the ſurface of the melted maſs; becauſe, by loſing part of its phlogiſton, it loſes alſo part of its ſpecific gravity, and laſtly it vitrifies.

Theſe vitrified and melted matters, accumulating more and more upon the ſurface of the metal while the operation advances, would conſequently protect this ſurface from the contact of air which is abſolutely neceſſary for the ſcorification of the reſt, and would thus ſtop the progreſs of the operation, which could never be finiſhed, if a method had not been contrived for their removal. This removal of the vitrified matter is procured either by the nature of the veſſel in which the melted matter is contained, and which being porous abſorbs and imbibes the ſcorified matters as faſt as it is formed; or by a channel cut in the edge of the veſſel through which the matter flows out.

The veſſel in which the refining is performed is flat and ſhallow, that the matter which it contains may preſent to the air the greateſt ſurface poſſible. This form reſembles that of a cup, and hence it has been called cupel. The furnace ought to be vaulted, that the heat may be applied upon the ſurface of the metal during the whole time of the operation. Upon this ſurface a cruſt or dark-coloured pellicle is continually forming. In the inſtant when all the imperfect metal is deſtroyed, and conſequently the ſcorification ceaſes, the ſurface of the perfect metals is ſeen, and appears clean and brilliant. This forms a kind of fulguration or corruſcation. By this mark the metal is known to be refined. If the operation be ſo conducted that the metal ſuſtains only the preciſe degree of heat neceſſary to keep it fuſed before it be perfectly refined, we may obſerve that it fixes or becomes ſolid all at once in the very inſtant of the corruſcation; becauſe a greater heat is required to keep ſilver or gold in fuſion, when they are pure, than when allayed with lead.

The operation of refining may be performed in ſmall or in large quantities, upon the ſame principles, but only with ſome differences in the management.

Large quantities of ſilver are thus purified, after the operations by which that metal is obtained from its ores. This ſilver, being always much allayed, is to be mixed with a ſufficient quantity of lead to complete its purification, unleſs lead has been added in its firſt fuſion from the ore, or unleſs it has been extracted from an ore which alſo contains lead; in which latter caſe, it is allayed naturally with a ſufficient quantity, or more than ſufficient, for the refining of it. See ORES of SILVER. One of the ores of this kind, which is treated in the beſt manner, is the ore of Ramelſberg in Saxony. The ſeveral operations which are practiſed in this country, abounding in mines and excellent metallurgiſts, have been exactly deſcribed by Schlutter. We ſhall here give a ſuccinct extract of the method of purifying large quantities of ſilver, from Hellot's tranſlation of Schlutter's work.

The workmen give the name of the work to the lead containing ſilver, obtained by ſmelting the ore of Ramelſberg. The firſt operation, called fining, upon this maſs of lead and ſilver, is performed in a furnace called a reverberatory furnace, from the vaulted form, which makes the heat reverberate upon the ſurface of the metal. This furnace is ſo conſtructed, that the flame of the wood, which is put in the fire-place through a hole called the fire-hole, is directed ſo as to circulate over the work within the furnace. The flame is thus directed by a current of air which is introduced through the aſh-hole, and paſſes out at an opening made at the ſide of the place where the work is. The wood is conſiderably ſaved by this direction of the flame. In the furnace a large cupel or teſt is to be diſpoſed. This teſt is to be made with aſhes of beech wood well lixiviated, that the ſalt may be waſhed from them. See CUPEL. In ſome founderies different matters are added to the aſhes, as ſand, lime, clay, calcined ſpar or gypſum. We may obſerve, concerning theſe additions, that they would be very injurious, and would make the teſt melt, if a ſtrong heat were applied; but the heat requiſite for fining is only moderate.

When the teſt is well prepared and dried, all the work is to be put into it at once, which is generally ſixty-four quintals: the fire is then to be made in the fire-place with ſaggots; but the fuſion is not to be too much haſtened, firſt, that the teſt may have time to dry thoroughly, which is very eſſential; for if any moiſture remained when the metal is melted, an exploſion might happen: ſecondly, becauſe the work of the ore at Ramelſberg, and of moſt others, is rendered impure by the mixture of many metallic matters, which ought to be ſeparated, otherwiſe they would ſpoil the litharge, and give a bad quality to the lead afterwards obtained from that litharge. Theſe extraneous matters found in the work of Ramelſberg are, copper, iron, and matt. As theſe ſubſtances are hard and refractory, they do not melt ſo ſoon as the work, if the heat be moderate; and beſides, as they are ſpecifically lighter than the mixture of lead and ſilver, they float upon the ſurface of theſe two metals when melted, in form of a pellicle or ſkin, which is to be taken off. Theſe impurities are called the ſcum or firſt droſs. The remainder forms alſo a ſcum, which appears when the work has received more heat, but before the litharge has begun to form. This is a ſcoria which is to be carefully taken off, and is called the ſecond droſs.

When the operation is come to this point, it is to be continued by means of bellows, the air of which is directed not on the wood, but on the ſurface of the metals, by means of iron plates placed for that purpoſe before the blaſt-hole, and which are called papillons. This air is not intended to increaſe the fire, but to facilitate the combuſtion of the lead, and to puſh the litharge to a channel in the oppoſite ſide of the teſt. This channel is called the way of the litharge, becauſe through this paſſage all the litharge, which is not imbibed by the teſt, flows out of the furnace. The litharge which is found in the middle of the largeſt lumps is friable, and crumbles into powder like ſand. It is put in caſks, each of which contains five quintals of it, and is ſold by the name of ſaleable litharge. The quantity of this is about one-half or one-third of the whole litharge that is formed. It is uſed for various purpoſes, and particularly for glazing earthen ware. The other part which remains is called cold litharge. It is re-melted and reduced to lead. This fuſion is called cold fuſion, and the lead produced from it, called cold lead, is good and ſaleable, when the work has been well purified from the extraneous matters mentioned above. The teſts impregnated with litharge are added to the ſame kind of ore when ſmelted; becauſe they contain not only much litharge which may be reduced to lead, but alſo ſome ſilver, in all refinings, whether in the large or ſmall way, as Mr. Tillet obſerves.

When about two thirds of the work are converted into litharge, no more litharge is formed: the ſilver is then covered with a ſort of white ſkin, which the refiners call lightening: and they call the metal lightened ſilver, or fined ſilver. The ſilver thus fined is not pure: every marc of it contains about four gros of lead: the purification of it is completed in the ordinary method; that is, by a ſecond cupellation with a hotter fire; which latter purification is called refining, and the perſons who perform it are called refiners. The workmen employed in this firſt operation or fining give improperly the name lightening to the white ſkin formed on the ſurface of the ſilver, when brought only to a certain degree of fineneſs; for we know that in eſſays the lightening or corruſcation above-mentioned does not appear but when the ſilver is perfectly fine, or at leaſt as fine as it can be made by cupellation.

A fining of ſixty-four quintals of work of Ramelſberg yields about eight or ten marks of fine ſilver, thirty-five or forty quintals of litharge, that is, from twelve to eighteen of ſaleable litharge, from twenty-two to twenty-three of cold litharge, from twenty to twenty-two quintals of teſts, and ſix or ſeven quintals of droſs. The operation laſts from ſixteen to eighteen hours.

If the ſilver before theſe operations was allayed by gold, it retains this gold ſtill after the fining and refining. The gold, if the quantity be conſiderable enough, may be ſeparated by parting. The operations for the purification of gold by cupellation are perfectly the ſame as thoſe of ſilver. If the gold to be fined contains ſilver, this ſilver remains with it after the operation; becauſe both theſe metals reſiſt the action of lead. The ſilver may afterwards be ſeparated by parting.

REFRACTORY. This word is applied to infuſible ſubſtances, or ſuch as cannot be fuſed by the heat of common furnaces.

REFRIGERATORY. A refrigeratory is a copper veſſel ſoldered round the capital of the alembic. Its uſe is to contain cold water, which is to be renewed when it is heated, and the hot water is to be let out at a cock fitted to the refrigeratory for this purpoſe. The intention of this renewal of the water of the refrigeratory is to keep perpetually cool the capital of the alembic, that the vapours of the liquor which riſe in diſtillation may be condenſed more eaſily and more quickly. Theſe refrigeratories were much uſed formerly, and all alembics were furniſhed with them: but modern diſtillers find that this veſſel is not attended with the advantages it was formerly believed to poſſeſs; for the diſtillation cannot ſucceed unleſs the capital of the alembic be as hot, or almoſt as hot, as the cucurbit. Mr. Baumé obſerved, that when the capital was cooled by very cold water, the diſtillation is ſoon ſtopped, and does not again begin till the capital is conſiderably heated.

The refrigeratory has for theſe reaſons been much neglected, and a worm ſubſtituted in place of it, which is indeed a kind of refrigeratory, but different from the other in this reſpect, that it is adapted to the noſe of the alembic, inſtead of ſurrounding the capital.

This remedy appears however to be in ſome meaſure inadequate, becauſe the head produces a conſiderable return of the ſpirit, even without a refrigeratory. It ſeems, nevertheleſs, that the inconvenience of this laſt addition ariſes merely from the large aperture of the neck. See SPIRIT, ARDENT.

REGISTER. Regiſters are openings in different parts of furnaces, which are to be ſhut occaſionally with ſtoppers of burnt clay. By means of regiſters we may govern the fire as we pleaſe; for, by opening or ſhutting them properly, we may not only increaſe or diminiſh the activity of the fire, but alſo we may apply its action more to one part of the furnace than another, by giving direction to the current of air which paſſes through it. Notwithſtanding the utility of regiſters, they are much neglected. Many chemiſts have diſuſed regiſters, probably becauſe they did not find the advantages from them which they expected. The reaſon of this is, that regiſters have hitherto been ill made. Their principal fault is, that they are generally too ſmall. A regiſter cannot have its proper effect unleſs it have an opening of two, three, or four inches for a furnace the internal diameter of which is a foot: but we frequently ſee furnaces of eighteen or twenty inches in diameter with regiſters the openings of which are ſcarcely eight or ten lines. Beſides, all thoſe who uſe furnaces are far from underſtanding their conſtruction.

REGULUS. The name regulus is given by chemiſts to metallic matters when ſeparated from other ſubſtances by fuſion. This name was introduced by all chemiſts, who, expecting always to find gold in the metal collected at the bottom of their crucibles after fuſion, called this metal, thus collected, regulus, as containing gold the king of metals. But although ſince the cultivation of philoſophical chemiſtry theſe metallic maſſes compoſed of ſeveral metals mixed together are occaſionally called by this name, yet it is more particularly applied to certain ſemi-metals which, having no proper name, generally received ſuch as the regulus of antimony, regulus of arſenic, and regulus of cobalt.

RESIN. The name of reſin is uſed to denote inflammable ſubſtances ſoluble in alcohol, uſually affording much ſoot by their combuſtion; they are likewiſe ſoluble in oils, but not at all in water.

All the reſins appear to be nothing elſe but volatile oils rendered concrete by their combination with vital air. The expoſure of theſe to the open air, and the decompoſition of acids applied to them, evidently prove this concluſion.

Reſins in general are leſs ſweet than the balſams. They afford more volatile oil, but no acid or ſaline matter, by diſtillation.

There are ſome among the known reſins which are very pure, and perfectly ſoluble in alcohol, ſuch as the balm of Mecca and of Copahu, turpentines, tacamahaca, elemi: others are leſs pure, and contain a ſmall portion of extract, which renders them not totally ſoluble in alcohol; ſuch are maſtic, ſandarach, guaiacum, labdanum, and dragon's blood.

1. The balſam of Mecca is a fluid juice which becomes thick and brown by age. It flows from inciſions made in the amyris opobalſamum. It is known by

the different names of balm of Judea, of Egypt, of Grand Cairo, of Syria, of Conſtantinople, &c.

Its ſmell is ſtrong, and inclining to that of lemons; its taſte is bitter, and aromatic.

This balſam, diſtilled by the heat of boiling water, affords much volatile oil.

It is balſamic, and is given incorporated with ſugar, or mixed with the yolk of an egg. It is aromatic, vulnerary, and healing.

2. The balſam of Copahu flows from a tree called Copaiba, in South America, near Tolu. It affords the ſame products, and poſſeſſes the ſame virtues as the foregoing.

3. The turpentine of Chios flows from the turpentine tree, which affords the piſtachios. It is fluid, and of a yellowiſh-white colour inclining to blue.

This plant grows in Cyprus, at Chios, and is common in the ſouth of France. The turpentine is obtained only from the trunk and large branches. Inciſions are made firſt at the lower parts of the tree, and afterwards by degrees higher up.

This turpentine, diſtilled on the water-bath, without addition, affords a very white, very limpid, and very fragrant oil: a more ponderous oil may be extracted at the heat of boiling water; and the reſidue, which is called boiled turpentine, affords by diſtillation, in the reverberatory furnace, a weak acid, a ſmall quantity of brown conſiſtent oil, and much coal.

The turpentine of Chios is very rare in commerce. Venice turpentine is extracted from the larix; its colour is a bright yellow, its conſiſtence limpid, its ſmell ſtrong and aromatic, and its taſte bitter.

The tree which affords it, is that which affords manna. Holes are bored during the ſummer near the bottom of the trunks of theſe trees, into which ſmall gutters or tubes are inſerted, to convey the juice into veſſels intended to receive it. The reſin is obtained only from trees in full vigour; the old trees very often have conſiderable depoſitions of reſin in their trunks.

This turpentine affords the ſame principles as that of Chios.

It is uſed in medicine as a detergent for ulcers in the lungs, kidneys, &c. either incorporated with ſugar, or mixed with the yolk of an egg, to render it more miſcible with aqueous potions. The ſoap of Starkey is made with this turpentine. The reſin known in commerce by the name of Straſburgh turpentine, is a reſinous juice of the conſiſtence of a fixed oil, of a yellowiſh-white colour, a bitter taſte, and a more agreeable ſmell than the preceding reſins.

It flows from the yew-leaved fir, which is very common in the mountains of Switzerland. This reſin is collected in bliſters, which appear beneath the bark in the ſtrong heats of ſummer. The peaſants pierce theſe veſicles with the point of a ſmall horn, which becomes filled with the juice, and is from time to time emptied into a larger veſſel.

The balm of Canada differs from the turpentine of fir in its ſmell only, which is more pleaſant. It is obtained from a ſpecies of fir which grows in Canada.

Oil of turpentine is more particularly uſed in the arts. It is the great ſolvent for all reſins; and as it evaporates, it leaves them applied to the ſurface of bodies on which the mixture has been ſpread. As reſins are the baſis of all varniſhes, alcohol and oil of turpentine muſt be the vehicles or ſolvents.

4. Pitch is a reſinous juice, of a yellow colour, more or leſs inclining to brown. It is afforded by a fir named Picea or Epicea. Inciſions are made through the bark; and the wound is renewed from time to time, as the lips become callous. A vigorous tree often affords forty pounds.

Pitch melted and expreſſed through bags of cloth is rendered purer. It is packed in barrels by the name of white pitch, or Burgundy pitch.

White pitch mixed with lamp-black, forms black pitch.

White pitch kept in fuſion becomes dry. The deſiccation may be facilitated with vinegar; and leaving it for a time over the fire, it then becomes very dry, and is called Colophony.

Lamp-black is the ſoot of burned pitch. It is likewiſe prepared by collecting the ſoot of pit-coal.

5. Galipot is a concrete reſinous juice, of a yellowiſh-white colour, and ſtrong ſmell. This juice comes from Guienne, where it is afforded by two ſpecies of pine, the pinus maritima, major et minor.

When theſe trees have acquired a certain ſize, a hole or notch is cut through the bark, near the bottom of the trunk. The reſin iſſues out, and flows into veſſels placed beneath to receive it. Care is taken to keep the wound open, and to renew it. The reſin flows during the ſummer; but that which iſſues out during the ſpring, autumn and winter, dries againſt the tree.

The pine likewiſe affords tar, and the oil called huile de Cade. For this purpoſe the wood of the trunk, branches, and roots, is heaped together and covered with turf, over which a fire is lighted, as if to convert them into charcoal. The oil which is diſengaged, not being at liberty to eſcape, falls to the bottom into a channel or gutter, which conveys it into a tub. The moſt fluid part is ſold under the name of huile de Cade; and the thicker part is the tar uſed for paying or painting the parts of ſhipping and other veſſels.

The combination of ſeveral reſins, coloured by cinnabar and minium, forms ſealing wax. To make the wax, take half an ounce of gum-lac, two drams of turpentine, the ſame quantity of colophony, one dram of cinnabar, and the ſame quantity of minium. The lac and the colophony are to be firſt fuſed, after which the turpentine is to be added, and laſtly, the colouring matters.

6. Maſtic has the form of white tares of a farinaceous appearance, having little ſmell, and a bitter aſtringent taſte. Maſtic flows naturally from the tree, but its produce is accelerated by inciſions. The leſſer turpentine tree, and the lentiſcus, afford that which is met with in commerce.

Maſtic affords no volatile oil when diſtilled with water. It is almoſt totally ſoluble in alcohol.

This reſin is uſed in fumigations. It is chewed, to ſtrengthen the gums; and it forms the baſis of ſeveral drying varniſhes.

7. Sandarach is a concrete reſinous juice, in dry white tranſparent tares, of a bitter and aſtringent taſte. It is obtained from moſt ſpecies of the juniper, and is found between the bark and the wood.

Sandarach is almoſt totally ſoluble in alcohol, with which it forms a very white varniſh, that dries ſpeedily. For this reaſon, the reſin itſelf is known by the French under the name of varniſh (vernis). Sandarach is not ſoluble in olive oil. See SANDARACH.

8. Labdanum is a black reſinous juice, dry and friable, of a ſtrong ſmell, and a diſagreeable aromatic taſte. It tranſudes from the leaves and branches of a kind of ciſtus which grows in the iſland of Candia. Tournefort, in his voyage

to the Levant, informs us, that when the air is dry, and the reſin iſſues out of the pores of the ciſtus, the peaſants ſtrike all the parts of theſe trees with a kind of whip, made of ſeveral thongs of leather fixed to the end of a ſtaff. The juice adheres to the leather, and is cleared off with a knife. This is pure labdanum, and is very rare. That which is known by the name of labdanum in tortis, is mixed with a very fine ferruginous ſand, for the purpoſe of increaſing its weight.

9. Dragon's blood is a reſin of a deep red in the maſs, but brighter when in powder. It has neither taſte nor ſmell.

It is obtained from the drakena, in the Canary Iſlands, from which it flows in tares during the dog-days. It is alſo obtained from the ptero-carpus draco. The parts are expoſed to the vapour of hot water; the juice iſſues out in drops, which are collected and wrapped up in the leaves of reeds.

The dragon's blood of the ſhops, which has the form of flattened orbicular loaves, is a compoſition of various gums, to which this form is given, after they have been coloured with a ſmall quantity of dragon's blood.

Dragon's blood is ſoluble in alcohol: the ſolution is red: the reſin itſelf may be precipitated of the ſame colour.

This reſin is uſed in medicine as an aſtringent.

RETORT. Retorts are veſſels employed for many diſtillations, and moſt frequently for thoſe which require a degree of heat ſuperior to that of boiling water. This veſſel is a kind of bottle with a long neck, ſo bent that it makes with the belly of the retort an angle of about ſixty degrees. From this form they have probably been named retorts. The moſt capacious part of the retort is called its belly. Its upper part is called the arch or roof of the retort, and the bent part is the neck.

Retorts differ in form and materials: their bellies are generally round: ſome of them are oblong, and ſhaped like a cucurbit; theſe are called Engliſh retorts. They are preferable for the diſtillation of matters which are ſubject to ſwell, and to paſs into the receiver before they be decompoſed.

A retort which has a little hole pierced in its roof is called a tabulated retort. This hole muſt be capable of being exactly cloſed with a ſtopper of proper materials. Retorts of this kind are employed in diſtillations, where ſome matter muſt be introduced into the retort after the receiver is joined to it, as in the diſtillation of ſmoking marine acid, and in the obſolete operations for procuring the ſeveral kinds of clyſſus.

If the retort be well made, the above-mentioned inclination of its neck muſt be moſt favourable to diſtillation. When the neck is too much inclined, the receiver cannot be conveniently luted to it, and is alſo by this form brought too near the furnace. If the neck be too little inclined, the vapours or liquors which riſe in diſtillation can ſcarcely flow into the receiver from want of ſufficient deſcent, and only circulate in the belly of the retort. Retorts, when too narrow in their bending, are very faulty. This form muſt be an impediment to diſtillation: the paſſage therefore from the belly to the neck of the retort muſt be free and wide, and gradually diminiſhing to the extremity of the neck or the mouth of the retort.

Retorts of different materials are uſed in chemical operations, of common glaſs, cryſtal-glaſs, ſtone-ware, and iron. Retorts of glaſs are uſed for all operations which require a leſs heat than is ſufficient for their fuſion. Earthen retorts are neceſſary where great heat is requiſite, as in the preparation of phoſphorus.

Iron retorts are not much uſed, as they can only ſerve for the diſtillation of ſubſtances which cannot act upon this metal; and as theſe ſubſtances are few in number, they can ſeldom be employed but for the diſtillation of mercury, and of animal matters.

REVERBERATORY. See Apparatus.

REVIVIFICATION. See Reduction.

RHAPONTIC. The roots of certain docks and ſome other plants raiſed in Europe approach to rhubarb in appearance, participate in ſome degree of its medicinal virtues, and are ranked among the officinal ſimples, under the names of Monks Rhubarb and Rhapontic. The common monks rhubarb is the root of the lapathum hortenſe latifolium C. B. broad-leafed garden-dock or patience. The rhapontic of the phyſick garden of Berlin, and which of all the ſorts comes the neareſt to the true rhubarb, is the lapathum folio rotundo alpinum, J. B. et Tourn., round-leaved mountain or garden dock. This root is the rhei rhapontici of Linnæus. It grows wild on the mountain Rhodope in Thrace, from whence it was brought into Europe, about the year 1610, by Alpinus: it bears the hardeſt winters of this climate, and is not unfrequent in our botanic gardens. It is of a duſky colour on the ſurface, and of a looſe ſpungy texture; conſiderably more aſtringent, but leſs purgative than rhubarb.

Sixteen drams of this root yielded Neumann with rectified ſpirit ſeven drams and a ſcruple of extract, and afterwards with water, three drams and a half, five drams and half a ſcruple remaining undiſſolved. On inverting the procedure and treating the ſame quantity of the root firſt with water and afterwards with ſpirit, he obtained ten drams two ſcruples of watery, and one ſcruple of ſpirituous extract; the reſiduum weighed five drams and a few grains.

The extracts made at firſt, whether by water or by ſpirit, contain the active matter of the rhapontic, both the ſecond extracts having little or no taſte. The yellow colour of the root is more perfectly taken up by ſpirit than by water, and more concentrated in the ſpirituous than in the watery extract. The ſpirituous extract is alſo ſtronger in taſte than the watery: on firſt taſting, they both prove ſweetiſh, but ſoon after diſcover a degree of pungency.

RHODIUM LIGNUM, roſe wood, a wood or root brought from the Canary iſlands; and aſpalathus, a ſimple of conſiderable eſteem among the ancients, but which has not come to the knowledge of latter times.

The writers on botany and the materia medica are much divided about the lignum rhodium, not only with regard to the plant which affords it, but likewiſe in their accounts of the drug itſelf. This confuſion ſeems to have ariſen from an opinion that the rhodium and aſpalathus are the ſame; whence different woods brought into Europe for the unknown aſpalathus were ſold again by the name of rhodium.

As to aſpalathus, the ancients themſelves diſagree; Dioſcorides requiring by this appellation the wood of a certain ſhrub freed from the bark, and Galen the bark of a root. At preſent we have nothing under this name in the ſhops. What was heretofore ſold among us as aſpalathus, were pieces of a pale-coloured wood brought from the Eaſt Indies, and more commonly called calambour.

The lignum rhodium of the ſhops is uſually in long crooked pieces, full of knots, which when cut appear of a yellow colour like box, with a reddiſh caſt: the largeſt, ſmootheſt, moſt compact, and deepeſt coloured pieces ſhould be choſen; and the ſmall, thin, or pale ones rejected. The taſte of this wood is lightly bitteriſh, and ſomewhat pungent; its ſmell very fragrant, reſembling that of roſes: when long kept, it ſeems to loſe its ſmell; but on cutting or rubbing one piece againſt the other, it ſmells as well as at firſt. Diſtilled with water, it yields an odoriferous eſſential oil, in very ſmall quantity. Rhodium is at preſent in eſteem only upon account of its oil, which is employed as an high and agreeable perfume in ſcenting pomatums and the like. But if we may reaſon from analogy, this odoriferous ſimple might be advantageouſly applied to nobler purpoſes; a tincture of it in rectified ſpirit of wine, which contains in ſmall volume the virtue of a conſiderable deal of the wood, bids fair to prove a ſerviceable cordial, not inferior perhaps to any thing of this kind.

RHUBARB. An ounce of rhubarb, reduced into groſs powder, yielded with highly rectified ſpirit of wine three drams of extract, and afterwards with water two drams two ſcruples and a half; the reſiduum weighed two drams twelve grains. By applying water firſt to another ounce, five drams two ſcruples and a half of extract were obtained, and of the reſiduum five grains only were ſoluble in ſpirit of wine. Rhubarb appears from theſe experiments to contain much more gummy or mucilaginous than reſinous matter; and hence ſpirituous tinctures of it are not precipitated or rendered milky by addition of water, like the tinctures of moſt other vegetables.

The yellow colour of rhubarb is remarkably leſs deſtructible than any other vegetable yellows. Aquafortis, and other acids which deſtroy the colour of ſaffron, turmeric, &c. make no change in that of rhubarb, or at moſt render it only turbid. Volatile alkali heightens the colour, and inclines it to red. Fixed alkaline ſalts have this effect in a greater degree. Solutions of green vitriol and other chalybeate liquors change the colour of infuſions of rhubarb to an inky blackneſs; a mark that this root is poſſeſſed of an aſtringent quality. The ſpirituous extract does not purge, although the extract made by water after ſpirit does, as if its purgative quality reſided chiefly in a combination of gummy and ſaline matter. Mr. Model affirms, that a conſiderable quantity of ſelenites is contained in rhubarb. In one experiment, he obtained ſix ounces of ſelenites from four pounds of rhubarb: and in another experiment he obtained no leſs than an ounce of ſelenites from two ounces and five drams of old rhubarb.

RISIGAL. See REALGAR.

ROASTING OF ORES. See the METALS and ORES.

ROCK CRYSTAL. See CRYSTAL ROCK, alſo QUARTZ.

ROCKETS. In the art of making fire-works, gunpowder conſtitutes the chief ingredient; but the proportion of it is very frequently varied according to the different uſes for which it is intended. For making theſe, meal-powder only is commonly employed, and mixed with an additional quantity of ſulphur and nitre, according to the different purpoſes for which it is intended; on which account the laſt ingredient is generally brought into the form of a powder, by ſolution and evaporation, during which latter operation it is continually ſtirred.

The mechanical operations of the above-mentioned art not belonging to this work, we ſhall only make mention of the different compoſitions which are to be made upon chemical principles, as laid down by Wiegleb. For fuzes, ſeven parts of meal-powder, five of nitre, and three of ſulphur; and for rockets, thirty-ſix parts of nitre, eight of ſulphur, and fourteen of charcoal are to be taken; in both theſe, the intention is that the powder ſhall only be fired by degrees. For blue-balls, are to be mixed together thirteen parts of nitre, three of ſulphur, $\frac{17}{32}$ parts of reſin, $\frac{7}{16}$ of ſaw-duſt, and $\frac{9}{16}$ of charcoal. Light-balls require, for the dry ſort, two parts of nitre, $\frac{1}{2}$ a part of ſulphur, $\frac{3}{16}$ of reſin, $\frac{2}{3}$ of ſaw-duſt, and $\frac{1}{2}$ a part of meal-powder; for the fuſible, 8 parts of ſulphur, 2 of nitre, and 4 of meal-powder. Fire-balls are compoſed of twenty parts of corned powder, ten of pitch, ſix of nitre, four of ſulphur, one of tallow, one of hemp, and two of linſeed-oil. Water-rockets require eight parts of meal powder, thirty-ſix of nitre, ſeven of ſulphur, and one of reſin. As theſe particular maſſes of fire are deſtined to reſiſt the air and water, and nevertheleſs to burn for a certain time, the oleaginous and combuſtible additions are requiſite, among which, the intent of the ſaw-duſt appears to be to prolong the conflagration. Among theſe alſo may be reckoned the Greek-fire, which in fact was not invented by a Greek, but by Callinicus of Heliopolis, who is ſaid to have uſed it at the ſiege of Conſtantinople. It cannot be decided with certainty what it properly was, or of what it was compoſed. According to the deſcription of it given in hiſtory, it was a liquid ſubſtance that was eaſily kindled, and extinguiſhed with difficulty, which burned upon water, and was thrown incloſed in bottles and pitchers, into the enemies ſhips, by which means they were ſet on fire. It is very probable that pitch, ſulphur, linſeed-oil, oil of turpentine or petrolium made a conſiderable part of its compoſition.

The variouſly coloured fire-works depend on various additions, by which the natural colour of gunpowder, when on fire, may be altered, and in which metallic ſubſtances, for the moſt part, ſuch as antimony, zinc, marcaſite, verdigriſe, &c. are employed. Thus alſo clean filings of iron produce what is called brilliant, or white-fire.

ROD, DIVINING. The divining wand is an inſtrument, by means of which many perſons have formerly pretended, and ſome do now pretend, to diſcover under what parts of the earth metals, treaſures, ores, water, ſalt, &c. lie hid, without digging the ground. They ſay, this diſcovery may be made by a perſon holding the wand horizontally, and by walking along in places where theſe matters are expected; and that when he arrives at a place under which any of the above-mentioned matters lie, the wand will be forcibly inclined towards that place: but that this experiment ſhould ſucceed, much faith ſeems to be required in the perſon who holds the wand, or rather in the ſpectators. Macquer poſitively affirms, that the power of this wand is a chimera, which owes its reputation to avarice, to ignorance and credulity.

The famous Father Kircher, in his Mundus Subterraneus, in which many intereſting particulars are found concerning mines, derides theſe ſuperſtitious practices, and denies, from his own experience, the truth of the aſſertions concerning them. He ſeems however to have ſome faith in ſympathies, and propoſes even new divining wands of his own invention; the effects of which, though more dependent on phyſical cauſes, are not however more certain. He believes, for inſtance, that a wand, one end of which ſhould be made of ſal-gem, and the other of wood, being ſuſpended and balanced above a mine of ſalt, would be inclined towards the ground; and he ſupports his opinion by an experiment. This experiment conſiſts in evaporating over the fire a ſolution of ſal-gem below the wand, which is by no means really made to incline by the ſalt. We need not be deeply learned in chemiſtry to diſcover, that the wand would have inclined in the ſame manner, if Father Kircher had evaporated pure water, inſtead of a ſolution of ſal-gem; becauſe the water would have equally well attached itſelf to the ſaline end of the wand; conſequently this experiment proves nothing.

The ſame author propoſes alſo to diſcover mines of mercury by employing a wand, one end of which is made of gold and the other of wood, in hopes that the emanations of the mercury would attach themſelves to the gold rather than to the wood, and would make it incline downwards. But this effect certainly cannot be produced unleſs the mercury was evaporating; for which purpoſe two conditions are neceſſary: 1. The mercury muſt be in a native metallic ſtate, and not mineraliſed, as it is in cinnabar; and 2. It muſt alſo be expoſed to the heat of ſome ſubterranean fire, by which it is volatiliſed and ſublimed, the ordinary heat of the earth being far too little for this purpoſe. This ſecond phyſical or chemical divining wand propoſed by Father Kircher is therefore no better than the former; and probably the ſame judgment may be paſſed upon all other wands made upon the ſame principles, and in imitation of theſe. Laſtly, the ſame author poſitively affirms, that he hung and balanced a wand, one half of which was made of alder-tree, and the other half of ſome wood that has no ſympathy with water, over a ſubterranean water, and that he obſerved the end of the wand which was made of alder incline towards the earth.

In addition to the above, which is from Macquer, I muſt remark that the divining rod ſtill poſſeſſes conſiderable reputation among the mere miners in our metallic counties. They pretend to eſtabliſh, from obſervation, that the experiment does not ſucceed unleſs the rod be held in the hand, or in other words, that an inanimate ſuſpenſion will not be ſufficient to produce the effect: And further, that there are certain individuals in whoſe hands the rod will be acted upon, but that with far the greater majority it has no effect. I will not here relate any of the narratives which have come to me at ſecond and third hand, wherein very rational precautions are affirmed to have been made in the trials; neither ſhall I give an opinion where for want of experience I have no good ground to form one. But I think the object is entitled at leaſt to ſome portion of enquiry, inſtead of a decided rejection, which might formerly with equal reaſon have been applied to ſome of the phenomena of magnetiſm, electricity, &c.

When we find, for example, that the ſame electric ſhock affects one individual ſtrongly, another leſs, and a third not at all; when we find that the nervous energy is excited, and produces motion in limbs * recently amputated when certain metals are applied conjunctively and not alone, ſuch as tin and ſilver, iron and gold, zinc and ſilver or gold; — when we obſerve that ſilver laid upon the tongue, and zinc inſerted in the noſtril, produce the appearance of a flaſh of lightning to the living individual the inſtant they are made to touch; which, though to moſt perſons evident and ſtriking, is much more ſo to ſome than to others;—it ſeems to be not improbable that other energies may exiſt among metals and minerals, which may ſhew themſelves in the divining rod or otherwiſe.

ROOF. Chemiſts and metallurgiſts uſe this word to denote the internal ſuperior ſurface of certain cavities. Thus they ſay the roof of a retort; the roof of a mine, &c.

ROSEMARY. This is a native of Spain, Italy, and the ſouthern parts of France, where it grows in abundance upon dry gravelly grounds; in the like ſoils it thrives beſt with us, and likewiſe proves ſtronger in ſmell, than when produced in moiſt rich ones: this obſervation obtains in almoſt all the aromatic plants.

Roſemary has a fragrant ſmell, and a warm pungent bitteriſh taſte, approaching to thoſe of lavender; the leaves and tender tops are ſtrongeſt; next to theſe the cup of the flower; the flowers themſelves are conſiderably the weakeſt, but

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* Valli on Animal Electricity.

moſt pleaſant. Aqueous liquors extract great ſhare of the virtues of roſemary leaves by infuſion, and elevate them in diſtillation; along with the water ariſes a conſiderable quantity of eſſential oil, of an agreeable ſtrong penetrating ſmell. Pure ſpirit extracts in great perfection the whole aromatic flavour of the roſemary, and elevates very little of it in diſtillation: hence the reſinous maſs left upon abſtracting the ſpirit, proves an elegant aromatic, very rich in the peculiar qualities of the plant. The flowers of roſemary give over great part of their flavour in diſtillation with pure ſpirit; by watery liquors their fragrance is much injured; by beating, deſtroyed. The officinal preparations of roſemary are, an eſſential oil from the leaves, or from the herb in flower, a conſerve of the flowers, and a ſpirit called hungary-water, from the flowery tops. The tops are uſed alſo in the compound ſpirit of lavender, cordial confection, and ſaponaceous balſam.

ROTTEN STONE. Tripoli; Terra Tripolitana. Is known by its quality of rubbing or wearing hard bodies, and making their ſurfaces to ſhine, the particles of the tripoli being ſo fine as to leave even no perceptible ſcratches on the ſurface. This poliſh may likewiſe be produced by other fine clays, when they have been burnt a little. The tripoli grows ſomewhat harder in the fire, and is very refractory: it is with difficulty diſſolved by borax, and with ſtill greater difficulty by the microcoſmic ſalt: it becomes white by ignition: when crude, it imbibes water, but is not diffuſible in it. It taſtes like common chalk, and is rough or ſandy between the teeth, although no ſand can by any means be ſeparated from it. It has no quality in common with other kinds of earths, by which it might be conſidered as a variety of any other. That which is here deſcribed is of a yellow colour, and is ſold by the colourmen, who do not know where it is found.

This earth was formerly brought to us from Tripoli in Barbary, whence this name was given to it. Fabroni enumerates the following characters:

1. This earth does not effervefce with any of the acids: and,

2. It becomes not only hard in the fire; but when conſiderable heat is applied, its ſurface becomes vitrified.

3. All tripolis, except thoſe found in England, acquire a red colour by being burnt.

4. They are fuſible with the calcareous earth, as well as with borax and with microcoſmic ſalt. But,

5. When waſhed in water, no other ſubſtance ſeparates from them. However,

6. Sometimes the marine acid and the vitriolic may be extracted by diſtillation from theſe earths.

It is found either ſolid, of a rough texture; a brown or yellowiſh colour; or ſpotted like marble; or elſe, friable and compact; of a granulated texture, and brown or yellowiſh colour. It is this laſt ſort which is found in England.

Da Coſta ſays he has procured the kind of yellow tripoli mentioned by Cronſtedt, from Scotland, where it had lately been diſcovered. But the rotten ſtone, ſo called, is another ſort, found in Derbyſhire. It is in common uſe here among workmen for all ſorts of finer grinding and poliſhing, and is alſo ſometimes uſed by lapidaries for cutting of ſtones.

The rotten ſtone of Derbyſhire is, according to Ferber, a tripoli mixed with calcareous earth.

Kirwan affirms that tripoli is evidently a volcanic product. For a coal mine at St. Eſtienne having accidentally taken fire, and the fire in its progreſs having extended to ſome ſtrata of ſhiſtus and bitumen, tripoli was found in thoſe parts of the ſtrata that the fire had acted upon, but not in any other. Mem. Par. 1769. p. 276. quoted by Kirwan.

Tripoli is found alſo of gray, white, and red colour. It contains 90 parts of ſiliceous earth, 7 of argill, and 3 of iron. Sometimes a little magneſia has been extracted from it.

ROUCOU. See Annotto, in addition to which article, the following is extracted from Berthollet:

The watery decoction of annotto has a ſtrong ſmell, and a diſagreeable taſte. Its colour is of a yellowiſh red, and it is ſomewhat turbid. An alkaline ſolution changes it to an orange yellow, which is brighter and more pleaſing; and a ſmall quantity of a whitiſh ſubſtance is ſeparated from it, which remains ſuſpended in the liquor. If we boil annotto in water with an alkali, it diſſolves much better than in water alone, and the liquor is of an orange colour.

Acids form with this liquor an orange-coloured precipitate ſoluble in alkalis, which communicate to it a deep orange colour; the ſupernatant liquor retains only a pale yellow.

Solutions of common ſalt and ſal-ammoniac produce no ſenſible change.

The ſolution of alum gives a conſiderable quantity of orange precipitate, which is deeper than that which acids produce; the liquor remains of a pleaſant lemon colour, bordering a little on green.

Vitriol of iron forms a precipitate of an orange brown; the liquor remains of a pale yellow.

Vitriol of copper gives a precipitate of a yellowiſh brown, ſomewhat brighter than the former; the liquor preſerves a greeniſh yellow colour.

A ſolution of tin produces a lemon-coloured precipitate, which is depoſited very ſlowly.

When annotto is uſed, it is always mixed with an alkali, which facilitates its ſolution, and gives a colour leſs inclining to red. It is cut in pieces, and boiled in a caldron, with an equal weight of cendre gravelée, provided the deſired ſhades do not require a ſmaller proportion of alkali; the cloth may be then dyed in this bath, either with theſe ingredients alone, or with the addition of others to modify the colour; but it ſeldom happens that annotto is uſed for wool, becauſe the colours it imparts are too fading, and may be obtained of a more durable nature by other means. Hellot employed it in dyeing a ſtuff prepared with alum and tartar, but the permanency of the colour was not much increaſed. It is almoſt ſolely uſed for ſilk.

For ſilks to be dyed of an aurora, or of an orange colour, it is ſufficient to ſcour them with twenty pounds of ſoap to the hundred; after they have been well cleanſed they may be immerſed in a bath of water, with which more or leſs of the alkaline ſolution of annotto (according to the ſhade required) has been carefully mixed. The heat of this bath ought to be between tepid and boiling water.

When the ſilk has acquired an uniform colour, one of the hanks muſt be taken out, waſhed and wrung, to ſee whether the colour be ſufficiently full; and if it be not, more ſolution of annotto muſt be added, and it muſt be turned again. This ſolution preſerves its colour unchanged.

When the deſired ſhade has been obtained, nothing remains but to waſh the ſilks, and to beetle them twice, by a ſtream of water, to free them from the ſuperfluous annotto, which would injure the beauty of the colour.

When raw ſilk is to be dyed, ſuch as is naturally white muſt be choſen, and it muſt be dyed in the annotto bath, which ought only to be tepid, or even cold, that the alkali may not diſſolve the gum of the ſilk, and deſtroy its elaſticity, which we wiſh to preſerve.

What has been now ſaid reſpects the ſilk intended to receive the aurora colour: to make the orange, which contains more red, after dyeing with annotto, it is neceſſary to redden the ſilks with vinegar, alum, or lemon juice. The acid, in ſaturating the alkali uſed to diſſolve the annotto, deſtroys the yellow ſhade which the alkali had imparted, and reſtores its natural colour, which inclines a good deal towards red.

For the very deep ſhades it is the practice at Paris, as Macquer informs us, to alum them; and if the colour is not yet red enough, to paſs them through a weak bath of braſil-wood. At Lyons, the dyers, who uſe carthamus, ſometimes employ the old baths made with that ingredient for the deep orange colours.

When orange colours have been reddened with alum, they muſt be waſhed in a ſtream of water; but it is not neceſſary to beetle them, unleſs the colour be too red.

Shades which preſerve a reddiſh hue may likewiſe be obtained by a ſingle operation, namely, by employing, in the preparation of the annotto bath, a ſmaller quantity of alkali than that above directed.

Mr. Guhliche adviſes us not to employ heat in the preparation of annotto. He directs that it ſhould be put into a glaſs veſſel, or one of earthen ware with a vitreous coat, and that as much ſolution of pure alkali ſhould be added as will cover it, and that this mixture ſhould be left at reſt for twenty-four hours; that the liquor ſhould then be decanted, and filtered, and the reſiduum repeatedly waſhed with water, leaving the mixture at reſt each time for two or three days, till the water no longer receives any colour; that theſe liquors ſhould be all mixed together, and put into a well-ſtopped veſſel, and kept for uſe.

He directs that the ſilk ſhould be ſteeped for twelve hours in a ſolution of alum, in the proportion of two ounces of the ſalt to a pound of the ſilk, or in water acidulated with the acetocitric acid before deſcribed p. 234; when taken out of this mordant, it is to be well wrung.

The ſilk thus prepared is put into the annotto bath quite cold, and kept there, and ſtirred about, until it has acquired the proper ſhade, or it is kept at a degree of heat far below ebullition; when taken out of the bath, it is waſhed and dried in the ſhade.

For the brighter ſhades, a liquor is employed, which is leſs loaded with colour, to which may be added a little of the acid liquor, which has been uſed as a mordant, or the dyed ſilk may be paſſed through acidulated water.

If we wiſh to have the laſt ſhades with leſs of an orange caſt, and approaching to nankeen, a ſmall quantity of ſolution of galls in white wine may be added to the bath.

To give an orange colour to cotton, Mr. Wilſon directs the annotto to be ground while it is kept moiſtened, boiled in water with double its weight of alkali, left to ſettle for half an hour, and the clear liquor to be put into a heated veſſel; in this the cotton is to be immerſed, when it will take an orange colour. A hot ſolution of tartar is then to be poured into the bath, ſo that it may become weakly acidulated; it is to be again turned in it on the ſkein ſticks, or wound upon the winch when in the piece; in this way the colour becomes more lively, and fixes better; they then waſh the cotton ſlightly, and dry it in a ſtove.

ROWLY RAG. This ſtone is of a duſky or dark gray colour, with numerous minute ſhining cryſtals. The town of Birmingham is paved with it.

Its texture is granular: by expoſure to the air, it acquires an ochrey cruſt.

Its ſpecific gravity is 2748.

Heated in an open fire, it becomes magnetic.

In ſtrong heat it melts per ſe, but with more difficulty than baſaltes.

According to Dr. Withering's analyſis, 100 parts of it contain 47,5 of ſiliceous earth, 32,5 of argil, and 20 of iron.

RUBICELLE. See Precious Stones, No. II.

RUBY. See Precious Stones, No. II.

RUBY, ARSENICAL. Realgar, or the red combination of arſenic and ſulphur, obtains a degree of tranſparency by fuſion and cooling, and is then diſtinguiſhed by this name.

RUST. Metals are ſaid to ruſt when their ſurface becomes calcined by expoſure to air and moiſture. The calx is alſo called ruſt. The word is more particularly applied to iron.

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SAFFLOWER. See Carthamus.

SAFFRE. See Zaffre.

SAFFRON. Crocus ſativus C. B. et Lin. The chives or fleſhy capillaments growing at the end of the piſtil of the flower, carefully picked and preſſed together into cakes.

There are three ſorts of ſaffron met with in the ſhops, two of which are brought from abroad, the other is the produce of our own country; this laſt is greatly ſuperior to the two former, from which it may be diſtinguiſhed by its blades being broader. When in perfection it is of a fiery orange red colour, and yields a deep yellowiſh tincture: it ſhould be choſen freſh, not above a year old, in cloſe cakes, neither dry nor yet very moiſt, tough and firm in tearing, of the ſame colour within as without, and of a ſtrong, acrid, diffuſive ſmell.

Both water and ſpirit extract the colour and virtue of ſaffron. The former liquor improves the ſmell and heightens the colour, whilſt the ſpirit ſeems rather to weaken both. By drying two ounces and a half of the beſt ſaffron in the heat of a water bath, half an ounce of liquor was obtained, which had an exceeding ſtrong ſmell, but had not the appearance of oil. This is the active part of the ſaffron, which diſorders the head and ſenſes. Six drams of extract were obtained from an ounce of dried ſaffron by means of water, and five drams and one ſcruple were obtained from another ounce by means of ſpirit. Rectified ſpirit acquired no ſmell or taſte by diſtillation from dried ſaffron; but water being thus diſtilled acquired a ſtrong ſmell.

SAFFRON, BASTARD. In this article I ſhall extract the account given by Berthollet, which was not publiſhed when the article CARTHAMUS went to the preſs.

Carthamus, or baſtard ſaffron (carthamus tinctorius), of which the flower only is uſed in dyeing, is an annual plant cultivated in Spain, Egypt, and the Levant. There are two varieties of it; one with larger leaves, the other with ſmaller. The latter is ſaid to be that of Egypt; where it makes a conſiderable article of trade.

Carthamus was formerly cultivated in Thuringia and Alſatia; but the preference given to that of the Levant has occaſioned its culture to be nearly abandoned in the more northern climates. The celebrated Beckmann, who has publiſhed a very intereſting diſſertation on carthamus*, has endeavoured to diſcover the difference between that produced with us, and that brought from the Levant: but, previous to his relating his obſervations, it will not be amiſs to give an account of the properties of this ſubſtance, ſuch as it is employed in dyeing.

Carthamus contains two kinds of colouring matter; the one yellow; the other red. The firſt alone is ſoluble in water: its ſolution is always turbid: with reagents it exhibits the appearances commonly obſerved in yellow colouring matter: acids render it lighter; alkalis make it deeper, and more approaching to orange: both produce a ſmall portion of fawn-coloured precipitate, by means of which it becomes clearer. Alum forms with it a deep yellow precipitate in ſmall quantity; ſolution of tin, and other metallic ſolutions, precipitates which have nothing remarkable.

Alcohol acquires but a ſlight tincture from the flowers, after all the yellow ſubſtance has been extracted by repeated waſhings. If theſe flowers be put into a ſolution of cauſtic alkali, they become yellow, and the liquor which is preſſed out is of a deep yellow colour. On ſaturating the alkali with an acid, the liquor becomes turbid, reddiſh, and gradually depoſits a very ſmall quantity of a reddiſh yellow precipitate. With ſolutions of alum, zinc, and tin, a yellow precipitate is formed; and with ſolutions of iron and copper, a precipitate inclining to green. If inſtead of a ſolution of cauſtic alkali, a ſolution of mild alkali be uſed, acids produce with it a more copious precipitate of a redder hue: but the redneſs differs according to the acid employed. Alum alſo produces with the latter alkaline ſolution, a red precipitate, which is ſo light that it generally ſwims on the ſurface of the liquor. This colouring matter is ſo delicate, and ſo eaſily changed, that if heat be employed to diſſolve it, the precipitates produced by acids will not have ſo fine a colour.

Mr. Beckmann has obſerved, that the carthamus of Thuringia contained much more of the yellow matter than that of the Levant: that, in other reſpects, the red matter of the former was by no means inferior in beauty to that obtained from the latter; yet that, to produce equal effects, half as much more of it was required. He next examined, whether this difference depended on the climate, or only on the mode of preparation.

Haſſelquiſt relates, in his Travels in Egypt, that when the flowers of carthamus are gathered, they are preſſed between two ſtones, to ſqueeze out the juice. After this they are waſhed ſeveral times with water, which in Egypt is naturally ſalt. When taken out of the water they are preſſed between the hands, and then ſpread on mats, placed on the flat roofs of their houſes, where they are covered in the day time, that the ſun may not dry them too faſt, but left expoſed to the dew at night. They are occaſionally turned, and, when ſufficiently dry, taken in, and kept for ſale under the name of ſaffranon.

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* Comment. Societat. Gotting. tom. iv. 1774.

If the carthamus of the Levant, ſuch as it is in commerce, be compared with that of Thuringia, the former will be found to be more pure, a little moiſt, and in compreſſed maſſes; the latter drier, and more elaſtic. Theſe differences depend on the preparation. Writers on agriculture, deceived by the erroneous name of baſtard ſaffron given to carthamus, have ſuppoſed that it ſhould be treated like ſaffron. Hence they direct it to be gathered in a dry ſeaſon, and dried with care. Mr. Beckmann thinks, on the contrary, that the mode adopted in Egypt ought to be imitated. He adviſes even to add a little ſalt to the water uſed in preparing it, to give it the quality it has naturally in Egypt.

The flower of carthamus has a fine colour of fire, but in drying it grows yellow. It ſhould not be gathered till it grows dry; and it is better, if it has been rained upon in that ſtate, though the contrary opinion is erroneouſly held. The want of rain may be ſupplied by watering the flowers morning and evening. When they are gathered, the ſeeds may be ſtill left to ripen.

The intention of theſe directions is to promote the ſeparation of the yellow matter, the abundance of which conſtitutes the difference between the carthamus of our climates and that of the Levant. Carthamus ſhould be kept in a moiſt place, as its becoming too dry would be injurious.

There are many reaſons to induce us to enrich our agriculture with this production. The ſeeds of carthamus are very good food for wild fowl, and particularly for parrots, whence they have received the name of grain de perroquet. An uſeful oil might be expreſſed from them, and the reſidue given to cattle. The dry leaves and ſtalks would ſerve as fodder for ſheep and goats in the winter; and thoſe ſtalks which are too large might be uſed as fuel, after they had ſtripped them. Mr. Beckmann has found the carthamus ripen well at Gottingen, where the ſoil is ſandy. The ground ſhould be moderately dunged; and the plant neither tranſplanted nor watered.

No uſe is made of the yellow ſubſtance of carthamus: but to extract that part, it is put into a bag and trodden in water till no more colour can be preſſed out. The flowers, which were yellow, become reddiſh in this operation, and loſe nearly half their weight: it is in this ſtate they are uſed.

The yellow ſubſtance might however be employed: and Mr. Poerner has made many experiments on the ſubject. The principal reſults of his experiments were, that wool without any preparation takes from it a yellow colour, which is not permanent; but that which it takes after having been prepared with alum and tartar, though not very laſting, is better. Mr. Beckmann aſſerts, that cloth prepared with tartar, or with tartar and alum, acquires from it a good yellow colour; and that carthamus contains more yellow colouring matter than an equal weight of fuſtic itſelf.

To extract the red part of carthamus, and afterwards apply it on the ſtuff, recourſe is had to the property alkalis poſſeſs of diſſolving it, and it is precipitated by means of an acid. It has been found, that lemon-juice produces the fineſt colour. Mr. Beckmann ſays that, next to this, the vitriolic acid produces the beſt effect, provided a proper quantity only be uſed: too much of it would alter and deſtroy the colour. According to Scheffer, the juice of the berries of the ſervice-tree (ſorbus aucupatorius) may be ſubſtituted for lemon-juice. It is thus prepared. The berries are bruiſed in a mortar with a wooden peſtle, and the expreſſed juice is left to ferment: it is then bottled, and the clear part, which is moſt acid, becomes fitter for uſe the longer it is kept. This operation requires ſome months, and ſhould be undertaken only in ſummer.

It has been ſeen, that the proceſs conſiſts in extracting the red colouring matter by means of an alkali, and precipitating it with an acid. From this precipitate is procured the rouge uſed by ladies. To make it, the ſolution of carthamus is prepared with cryſtals of ſoda, and precipitated by lemon-juice, which has ſtood ſome days to ſettle. It has been remarked, that lemons beginning to decay were fitter for this purpoſe than thoſe leſs ripe, the juice of which retains much mucilage. The precipitate of carthamus is dried on plates of delft with a gentle heat: from theſe it is ſeparated, and ground very accurately with talc, previouſly reduced to a very ſubtile powder by means of the leaves of ſhave-graſs, and paſſed ſucceſſively through ſieves of different degrees of fineneſs. The fineneſs of the talc, and its proportion to the precipitate of carthamus, make the difference between the cheaper and dearer rouges.

Wool may be dyed red by means of carthamus, as Mr. Beckmann has experienced; but this red ſoon changes towards an orange: and as the fineſt and moſt various reds may be obtained from cochineal, which are at the ſame time much more permanent than thoſe of carthamus, the uſe of the latter for wool is relinquiſhed.

Carthamus is uſed for dyeing ſilk poppy colour, a bright orange red (nacarat) cherry, roſe, and fleſh colour. The proceſſes differ according to the intenſity of the colour to be given, and the degree in which it approaches that of fire: but the carthamus bath, which varies in the mode of uſing, is prepared as follows:

After having extracted the yellow matter of the carthamus, and opened the cakes, it is put into a deal trough, where it is ſprinkled at different times with ſoda, or cendres gravelées, the former of which is beſt, well powdered and ſifted, in the proportion of ſix pounds to a hundred; mixing it well as the alkali is put in. This operation is called ameſtrer. The carthamus thus mixed with the alkali, is put into a ſmall trough with a grated bottom, firſt lining it with a cloſely woven cloth. When this trough is nearly half filled, it is placed upon the large one, and cold water is poured on it, till the lower trough is full. The carthamus is then ſet over another trough, till the water comes from it almoſt colourleſs. A little more alkali is then added, and freſh water is poured on. Theſe operations are repeated, till the carthamus is exhauſted, and becomes yellow.

The ſilk being diſtributed on the rods in hanks, lemon-juice, which comes from Provence in caſks, is poured into the bath, till it is of a fine cherry colour. This is called turning (virer) the bath. Having ſtirred the bath well, the ſilk is dipped in, and turned on the ſkein ſticks as long as it appears to get any colour. For poppy colour, it is taken out, wrung, drained on the pegs, and paſſed through a new bath, where it is treated as in the former. It is then dried, and paſſed through freſh baths, waſhing and drying it after every operation, till it has obtained the depth of colour required. When it is at the proper point, it is brightened, by turning it ſeven or eight times in a bath of hot water, to every bucket of which about a gallon of lemon-juice is to be added.

When ſilk is to be dyed poppy or fire colour, it muſt be firſt ſcoured as for white, and muſt then have a ſlight annotto ground, in the manner deſcribed in that article. This ſilk ought not to be alumed.

Bright orange, reds, and deep cherry colours, are treated exactly in the ſame way as poppy colour, except that they have not the annotto ground, and that they may be dipped in the baths that have been already uſed for poppy colour, which will exhauſt them. Freſh baths are never made for theſe colours, unleſs the dyer has no occaſion for a poppy.

The lighter cherry colours, roſe colours of every ſhade, and fleſh colours, are made from baths of the ſecond and third runnings of the carthamus, which are weaker than the firſt. In theſe the deepeſt ſhades are firſt dipped.

The lighteſt of all theſe ſhades, which is a very pale fleſh colour, requires a little ſoap to be put into the bath: this ſoftens the colour, and prevents it from taking too quickly or unevenly. The ſilk is then waſhed, and brightened a little in the bath which has been uſed for brightening the deeper colours.

All theſe baths are uſed as ſoon as they are made, and as quickly as poſſible, as by keeping they loſe much of their colour, which would even be entirely loſt after a time. They are alſo uſed cold, becauſe the red feculæ loſe their colour on being expoſed to heat. The reader muſt have obſerved, that in the above experiments, cauſtic alkalis attack the delicate colour of carthamus, and turn it yellow: on this account cryſtals of ſoda ſhould be preferred to any other alkali. At leaſt we ſhould chooſe one that contains moſt carbonic acid, as ſalt of tartar.

To leſſen the expence of carthamus, it is uſual, for deep ſhades, to mix with the firſt and ſecond bath about a fifth of the bath of archil.

When raw ſilk is to be dyed, that which is very white ſhould be choſen and treated as boiled ſilk, with this difference only, that the poppy colours, bright orange, reds, and cherry colours, are paſſed through baths that have been uſed for the ſame colours for ſcoured ſilk, becauſe the raw ſilk in general takes colours more readily.

Poppy colour prepared in an acid liquor reſiſts the action of vinegar, but it ſoon changes and fades in the air. Scheffer ſays, that when he uſed the juice of ſervices inſtead of lemon-juice, the colour ſtood ſomewhat longer.

Mr. Beckmann has made ſome experiments on applying the red colour of carthamus to cotton. Having macerated cotton two hours in melted lard, he waſhed it well, and dyed it in the common way, with carthamus deprived of its yellow matter. This cotton took a deeper colour than ſome which had undergone no preparation. Soap ſucceeded equally well; and olive oil ſtill better. Mr. Beckmann then dipped his cotton in oil repeatedly, drying it each time. After the laſt drying he waſhed and dried it, and then paſſed it through the yellow bath of carthamus, to which he added galls and alum. Finally, he dyed it with the alkaline ſolution of carthamus and lemon-juice. By theſe means he obtained a fine full red. Cotton treated in the ſame manner, without having been impregnated with oil, took a colour of the ſame kind, but leſs full, and leſs capable of ſtanding the action of the air. From theſe experiments he thinks that cotton, to be dyed with carthamus, ſhould receive a preparation ſimilar to that given it for the Adrianople red.

To dye cotton poppy colour, Mr. Wilſon directs the carthamus, thoroughly freed from the yellow colouring matter, to be put into a veſſel, at the bottom of which is a hair ſieve, and to pour on it a ſolution of pearl-aſhes, mixing them well, and leaving them to ſtand all night. The next morning the liquor is to be drawn off by a cock at the bottom of the veſſel, and the cotton to be dyed is to be put into it and turned by means of a winch. In the mean time a ſolution of tartar is prepared, and left to ſettle; and whilſt it is yet hot, it is poured into the carthamus bath, till the liquor is rendered a little ſour. The cotton muſt continue to be turned in this, till it has acquired the proper ſhade. It is then waſhed lightly, and dried in a ſtove. In this way it obtains a fine colour.

To give cotton a ſcarlet, it muſt firſt be dyed yellow in the manner directed under the article Annotto, and whilſt yet wet, muſt be dyed with carthamus, in the manner juſt deſcribed. It thus acquires a fine ſcarlet; but it is not permanent, and will not ſtand waſhing.

SAFFRON OF METALS, is crude antimony, half deprived of its ſulphur and partly calcined by detonation of crude antimony with nitre, and afterwards well waſhed; or it is liver of antimony deprived of all ſaline matter by a ſufficient waſhing. This preparation is a violent and uncertain emetic, not uſed by prudent phyſicians.

SAGAPENUM. A concrete juice brought from Alexandria, either in diſtinct tears, or run together in large maſſes. It is outwardly of a yellowiſh colour; internally, ſomewhat paler, and clear like horn; grows ſoft upon being handled, and ſticks to the fingers: its taſte is hot and biting; the ſmell diſagreeable, by ſome reſembled to that of a leek, by others to a mixture of aſafœtida and galbanum.

An ounce of the purer ſort, examined by Neumann, with rectified ſpirit of wine yielded in digeſtion five drams and ſix grains of reſinous extract: the remainder, boiled with water in a cloſe veſſel ſo long as it gave out any thing to the menſtruum, yielded five ſcruples and eight grains of gum, one dram and five grains being left undiſſolved. Another ounce, treated firſt with water, gave two drams two ſcruples and a half of gummy extract; and afterwards with rectified ſpirit, four drams and one grain of reſin, one dram and ſix grains being left. The diſtilled ſpirit is ſenſibly, and the diſtilled water ſtrongly, impregnated with the flavour of the ſagapenum: along with the water ariſes a conſiderable portion of actual oil.

SAGO. This is the produce of an oriental tree, called by C. Bauhine palmam referens arbor farinifera. The medullary part of the tree of a middle age or growth, is beaten with water, and made into cakes, which are uſed by the Indians as bread. They likewiſe put the powder into a funnel, and waſh it with water over a hair-ſieve, which allows only the finer part to paſs through the water. The water, on ſtanding, depoſits the fecula; which being paſſed through perforated copper-plates is formed into the grains called ſago. It forms an agreeable jelly with water, milk, or broth, and is much uſed in phthiſical and convaleſcent caſes.

SAL AMMONIAC. See Ammoniacal Salts.

SALMIAC. A word ſometimes uſed for ſal ammoniac.

SALTS. Salts or ſaline bodies formerly conſtituted a principal diviſion of chemical matters. The characters attributed to them were a ſtrong tendency to combination, ſapidity, ſolubility in water, and incombuſtibility. But the accuracy of modern ſcience has ſhewn that theſe properties, and all others which can be ſelected to diſtinguiſh ſuch bodies which are admitted to be ſaline, are attended with conſiderable uncertainty. The tendency to combination is univerſal, and no leſs ſtrong in many other bodies than in a large number of the ſalts. Sapidity is evidently no leſs general. Solubility in water is ſcarcely perceptible in a great number of ſaline compounds, and is a marked character in others not ſaline, ſuch as ardent ſpirit, ether, mucilage, ſerum, and the like. Neither is the incombuſtibility of ſalts more excluſive than their other attributes. The mineral kingdom abounds with incombuſtible matters, which are not ſalts; and there are ſalts, ſuch as the acid of benzoin, the volatile alkali, and others more compounded, which are not deſtitute of this property. The true limits which divide ſalts from other bodies have not therefore been aſcertained. Whence it ſeems reaſonable to infer, not ſo much the difficulty of the ſubject, as that the diviſion itſelf appears to be of little utility.

Solubility in water is retained by modern chemiſts as a diſtinctive character of ſalts, but in an arbitrary and indiſtinct way. Thus it is remarked, that all bodies known only by the name of ſalts are ſoluble in leſs than two hundred times their weight of boiling water. A ſurer way of rendering this diſtinction uſeful conſiſts in attending to the component parts. Alkalis, acids, and ſuch compounds as they enter into, are diſtinguiſhed generally by the name of ſalts. The two former are called ſimple ſalts. Compounds of alkali and acid are called neutral ſalts. Bergman diſtinguiſhes the compounds of acid and metal by the name of middle ſalts, but it may perhaps be more convenient to uſe the accepted term metallic ſalts. No appropriate name has been given to the combinations in which the ſaline character is produced by an alkali without an acid.

An enumeration of all the ſalts, ſimple and compound, together with an account of their characters, would comprehend the whole of chemical ſcience. For there are no bodies in nature which are not capable of uniting with ſome ſaline ſubſtance. We ſhall, therefore, refer the reader to the articles Acids, and Alkalis, for the properties of thoſe ſalts, and their compounds; and to the reſpective earths and metals, for the ſalts of which they conſtitute the baſes. For a general arrangement or enumeration and their component parts, the article Nomenclature, and the Table of Principles in our Appendix, may be conſulted.

SALT, COMMON. The cryſtals of common ſalt are right angled ſix-ſided ſolids, and are uſually ſaid to be cubes. Theſe form at the ſurface, where the evaporation is the greateſt; and they float by virtue of the repulſive power of their dry upper ſurfaces, which diſplace a quantity of the ſurrounding water: a circumſtance common to all ſuch ſmall bodies as are not eaſily wetted. When the cryſtal becomes too large to be ſuſpended in this way, it ſinks. If two floating cryſtals come ſo near each other as that the hollow ſpaces may communicate, they fall together into one cavity at the ſurface, without ſinking; and the ſucceſſive appoſition of other cryſtals often produces a curious hollow pyramid, which is ſquare, becauſe the figure of the cryſtals themſelves occaſions them to apply to each other only in the poſition required to produce ſuch a ſolid.

Common ſalt does not alter in the air: but, when expoſed to heat, it cracks and flies in pieces, by the eſcape of its water of cryſtallization. A greater heat ignites and melts it; and a ſtill greater cauſes it to riſe totally in white fumes. The action of ſea-ſalt upon earths is not conſiderable. It aſſiſts the fuſion of ſiliceous earth; and is thrown into the furnace wherein the pottery called ſtone-ware is baked, where it riſes in fumes, and glazes their ſurface; probably by the combination of its alkali with the ſiliceous earth contained in the clay.

Common ſalt is found in large maſſes, or in rocks under the earth, in England and elſewhere. In the ſolid form it is called ſal gem or rock ſalt. If it be pure and tranſparent, it may be immediately uſed, in the ſtate in which it is found; but if it contain any impure earthy particles, it ſhould be previouſly freed from them. In ſome countries it is found in incredible quantities, and dug up like metals from the bowels of the earth. In this manner has this ſalt been dug out of the celebrated ſalt mines near Bochnia and Wieliczka, in Poland, ever ſince the middle of the 13th century, conſequently theſe 500 years, in ſuch amazing quantities, that ſometimes there have been 20,000 ton ready for ſale. In theſe mines, which are ſaid to reach to the depth of ſeveral hundred fathoms, 500 men are conſtantly employed. The pure and tranſparent ſalt needs no other preparation than to be beaten to ſmall pieces, or ground in a mill. But that which is more impure muſt be elutriated, purified, and boiled. That which is quite impure, and full of ſmall ſtones, is ſold under the name of rock ſalt, and is applied to ordinary uſes; it may likewiſe be uſed for ſtrengthening weak and poor brine-ſprings.

Though the ſalt mines of Wieliczka, near Cracow in Poland, have long aſtoniſhed the philoſopher and traveller, yet it deſerves to be remarked, that the quantity of rock ſalt obtained from the mines of Northwich is greatly ſuperior to that obtained at Cracow. The Biſhop of Llandaff affirms that a ſingle pit, into which he deſcended, yielded at a medium 4000 tons of ſalt in a year, which alone is about two thirds of that raiſed in the Poliſh mines. This rock ſalt is never uſed on our tables, in its crude ſtate, as the Poliſh rock ſalt is; and though the pure tranſparent ſalt might be uſed with our food, without any danger, yet it is prohibited under a penalty of 40s. for every pound of rock ſalt ſo applied. It is partly purified in water, and a great part of it is ſent coaſtwiſe to Liverpool and other places, where it is uſed either for ſtrengthening brine-ſpings or ſea-water.

Beſides the ſalt mines here mentioned, where the common ſalt is found in a concrete ſtate, under the name of rock ſalt, there is at Cordova, in the province of Catalonia in Spain, a remarkable ſolid mountain of rock ſalt: this mountain is between four and five hundred feet in height, and a league in circuit; its depth below the ſurface of the earth is not known. This mountain contains the rock ſalt without the leaſt admixture of any other matter. Vid. l' Hiſtoire Naturelle de l'Eſpagne, p. 406; or Dr. Watſon's Chemical Eſſays, vol. ii.

The waters of the ocean every where abound with common ſalt, though in different proportions. The water of the Baltic ſea* is ſaid to contain one ſixty-fourth of its weight of ſalt; that of the ſea between England and Flanders contains one thirty-ſecond part; that on the coaſts of Spain one ſixteenth part; and between the tropics it is ſaid, perhaps erroneouſly, to contain from one eleventh to one eighth part.

The water of the ſea contains, beſides the common ſalt, a conſiderable proportion of magneſian marine ſalt, and ſome gypſum, or lime combined with vitriolic acid. The magneſian ſalt is the chief ingredient of the remaining liquid which is left after the extraction of the common ſalt, and is called the mother water. Sea water, if taken up near the ſurface, contains alſo the putrid remains of animal ſubſtances, which render it nauſeous, and in a long continued calm cauſe the ſea to ſtink.

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* Romé de l'Iſle's Cryſtallographie, vol. i. p. 375, quoted by Magellan in his improved edition of Cronſtedt, p. 360.

The whole art of extracting ſalt from waters which contain it, conſiſts in evaporating the water in the cheapeſt and moſt convenient manner. In England, a brine compoſed of ſea water, with the addition of rock ſalt, is evaporated in large ſhallow iron boilers; and the cryſtals of ſalt are taken out in baſkets. In Ruſſia, and probably in other northern countries, the ſea water is expoſed to freeze; and the ice, which is almoſt entirely freſh, being taken out, the remaining brine is much ſtronger, and is evaporated by boiling. In the ſouthern parts of Europe the ſalt-makers take advantage of ſpontaneous evaporation. A flat piece of ground near the ſea is choſen, and banked round, to prevent its being overflowed at high water. The ſpace within the banks is divided by low walls into ſeveral compartments, which ſucceſſively communicate with each other. At flood tide, the firſt of theſe is filled with ſea water; which, by remaining a certain time, depoſits its impurities, and loſes part of its aqueous fluid. The reſidue is then ſuffered to run into the next compartment; and the former is again filled as before. From the ſecond compartment, after a due time, the water is transferred into a third, which is lined with clay well rammed and levelled. At this period the evaporation is uſually brought to that degree, that a cruſt of ſalt is formed on the ſurface of the water, which the workmen break, and it immediately falls to the bottom. They continue to do this, until the quantity is ſufficient to be raked out, and dried in heaps. This is called bay ſalt.

In ſome parts of France, and alſo on the coaſts of China, they waſh the dried ſands of the ſea with a ſmall proportion of water, and evaporate this brine in leaden boilers.

There is no difference between this ſalt and the lake ſalt extracted from different lakes, excepting ſuch as may be occaſioned by the caſual intervention of ſome ſubſtances. In this reſpect the Jeltonic ſalt-water lake in the Ruſſian dominions near Saratow and Dmitrewſk, deſerves our attention. In the year 1748, when the Ruſſians firſt fetched ſalt from thence, the lake was almoſt ſolid with ſalt; and that to ſuch a degree that they drove their heavy waggons over it, as over a frozen river, and broke up the ſalt. But ſince the year 1757, the water has increaſed ſo much, that at this preſent time it is nothing more than a lake very ſtrongly impregnated with ſalt. The Jeltonic lake ſalt contains at the ſame time alum and Epſom ſalt.

At ſeveral places in Germany, and at Montmarot in France, the waters of ſalt ſprings are pumped up to a large reſervoir at the top of a building or ſhed; from which it drops or trickles through ſmall apertures upon boards covered with bruſh-wood. The large ſurface of the water thus expoſed to the air cauſes a very conſiderable evaporation; and the brine is afterwards conveyed to the boilers for the perfect ſeparation of the ſalt.

The works at Montmarot are thus deſcribed by Fourcroy:

The water of the ſprings is conveyed by pumps into a large reſervoir placed at the top of a ſhed of a peculiar conſtruction. Under this ſhed are ſuſpended boards covered with little faggots of thorns. The water falling upon thoſe faggots through ſmall cocks, is divided into very minute drops: and as it thus expoſes a great deal of ſurface to the air circulating rapidly under the ſhed, nearly two thirds of it is evaporated. What is depoſited on the faggots is ſulphate of lime, or ſelenite. And when the liquor, upon trial with an inſtrument for the purpoſe, is found to be charged with ſalt to a certain degree, it is conveyed into large iron boilers ſupported by bars of the ſame metal, which croſs the bottom of the veſſels, and reſt on pieces of wood placed on each ſide. Theſe boilers, which are called ſtoves, are very large and ſhallow, and hold an hundred hogſheads of the ſalt water. They are then urged with a ſtrong fire. When the water boils up in large bubbles, it is at firſt muddy, and ſoon depoſits an ochreous earth on its ſurface in the form of a ſcum. A ſalt which is ſcarcely ſoluble, and is called by the workmen ſchlot, is next ſeparated: this ſalt is nothing but ſulphate of lime mixed with a little muriate of ſoda, ſulphate of ſoda, and earthy muriates. See Nomenclature. It is conveyed by the circulation of the boiling liquor into little troughs placed round the ſides of the boilers for the purpoſe. Theſe troughs are taken out and cleared from time to time, till a great quantity of ſmall cubical cryſtals, called by the workmen pieds de mouches, are obſerved floating on the ſurface of the liquor. They are then taken away for the laſt time. The fire is diminiſhed, and the muriate of ſoda is taken off with ladles as faſt as it is cryſtallized. The evaporation is thus continued as long as the water continues to afford cryſtals. The ſalt thus obtained is in larger or ſmaller cryſtals, according to the ſlowneſs or rapidity of the evaporation. The water which remains when cryſtals are no longer obtained, is called mother water, and contains earthy muriates.

Wallerius gives an account of a fourth proceſs for obtaining ſalt from ſea water, which is practiſed in the north. The water is confined in trenches on the ſhore: as it forms but a ſmall ſtratum, the cold ſoon penetrates through and freezes it. But as that portion neceſſary for the ſolution of the ſalt contained in the whole quantity of water cannot be converted into ice, what remains fluid contains all the ſalt, and is ſo concentrated that the moſt moderate heat cauſes it to afford muriate of ſoda in cryſtals: it is then conveyed into leaden boilers, and evaporated by fire.

The decompoſition of common ſalt, ſo as to ſeparate the alkali, has not been cheaply enough effected for the purpoſes of commerce. Litharge unites with the acid, and diſengages the alkali. See Alkali Mineral, alſo Lead. Kirwan has uſed ſugar of lead for the ſame purpoſe.

SALT, SPIRIT OF. The marine acid was formerly called ſpirit of ſalt, but this appellation has long ſince been diſuſed by philoſophical chemiſts. But it is ſtill the name of the article in commerce. See Acid Marine.

SALTPETRE. See Nitre.

SAND. Sand is an aſſemblage of ſmall ſtones. It is uſually produced by the mechanical diviſion ariſing from agitation in water. All ſtones but thoſe of the ſiliceous order are ſo ſoft, that the comminution thus produced is uſually carried in them to an extreme degree, ſo as to form duſt or mud, and their diſpoſition to unite or adhere together commonly produces ſtones of a different texture from that before poſſeſſed by the particles. In this way it appears that chalks, clays, marles, and other conſiſtent matters may be formed out of harder or more ſymmetrical materials worn down. But the ſiliceous earth being not only very hard, but likewiſe indiſpoſed to adhere together, retains the form of ſand as ſoon as the parts have become ſo ſmall as to be deficient in the weight requiſite to enable the parts to ſhake and break each other. Sand is therefore always underſtood to denote a ſiliceous matter.

The chief uſes of ſand in chemiſtry are in compoſitions for pottery and glaſs. Some ſands are more and ſome leſs fuſible, according to the various hard ſtones from which they may have originated. The ſize of the particles is of ſome importance in theſe works. As an alkali in fuſion diſſolves ſiliceous earths in leſs time the greater the ſurface of action, or, which is the ſame thing, the finer the particles of ſand, this kind is accordingly preferred for vitrifications.

SAND-BATH. See BATH.

SANDARACH. A name ſometimes given to the combination of arſenic and ſulphur. See ORPIMENT.

SANDARACH GUM. A reſin in white tears, poſſeſſing a conſiderable degree of tranſparency. It is obtained from the juniper tree, in which it occupies a place between the bark and the wood. Its powder is well known by the name of pounce, to be applied to paper when the ſize has been ſcraped off by eraſion. It is not a pure reſin, though water appears to have little if any action upon it. Three or four tears were put into pure ardent ſpirit. No remarkable appearance happened; but the next day it was found diſſolved with a mucilaginous fluid at the bottom of the veſſel, which by agitation became uniformly diffuſed through the fluid, and rendered it ſemi-opake. Reſin is ſoluble in tallow, by the aſſiſtance of heat; but gum ſandarach, treated in the ſame manner, emitted bubbles, ſwelled up, and enlarged its dimenſions greatly; then became brown, imperfectly fluid, and emitted ſmoke or fume of the peculiar ſmell of the reſin. The tallow did not appear to have ſuffered any other alteration than that it became browniſh. The gum ſandarach, apparently not at all diſſolved, was criſp or friable.

SANDIVER, or Glaſs-gall. This is a ſaline matter, which riſes as a ſcum in the pots or crucibles in which glaſs is made.

This matter is chiefly compoſed of Glauber's ſalt, common ſalt, vitriolated tartar, or other neutral ſalts which cannot enter into vitrification, and which were originally contained in the aſhes or alkalis employed in the compoſition of glaſs. Glaſs-gall is uſed to facilitate the fuſion of certain ores, and in eſſays; but this matter muſt vary much, according to the kinds of alkalis or aſhes from which it is produced.

SAP, or water colours, are of that nature, that they are capable of being entirely diſſolved in water, but are by no means miſcible with oils. They are of a viſcid nature; whence they ſtand in no need of any cementing ſubſtance, neither do they dry eaſily for this ſame reaſon, and are tranſparent. All colouring juices and extracts inſpiſſated by evaporation may be uſed with this intention: as for inſtance, a decoction of brazil-wood prepared with alum, and inſpiſſated; extract of ſaffron, refined Brunſwick green, cryſtallized verdegriſe, an aqueous extract of litmus with the addition of a little alkali, gamboge, ſapgreen, and the inſpiſſated decoction of the green huſks of walnuts. Of theſe, ſapgreen is prepared from the expreſſed juice of buckthorn-berries not perfectly ripe (Rhamnus catharticus Lin.) by gentle evaporation to the conſiſtence of honey. The ſap muſt be well clarified before it is evaporated. When it is inſpiſſated, as much alum, or, which is ſtill better, ſugar of lead, is to be mixed with it by little and little over the fire, as is requiſite to produce the fineſt green colour. A redundancy of theſe additions is prejudicial. The complete exſiccation muſt be made with a gentle heat, in ſaucers. The litmus above mentioned, which however contains a blue ſap-colour, is prepared in the large way in the manufactories of Holland. Ferber gives the following deſcription of it: Archil (Lichen rocella) is to be mixed with urine, lime-water, ſlaked lime, and ſome pot-aſh, in ſeveral large ciſterns, which muſt be kept under ſhelter, and ſuffered to ſtand for ſeveral weeks. By this means the maſs is rendered ſoft, and paſſes over to a kind of fermentation or evolution of its particles, and of the colouring matter contained in them. Now and then it is ſtirred, and ſuffered to ſtand macerating, till the maſs is become quite blue, and is converted into a muddy kind of pulp. Upon this the whole mixture is ground in a mill conſtructed for the purpoſe, and the pulpy magma dried in moulds. Hitherto alſo may be referred the fine ſap-blue diſcovered by Dr. Struve. In order to make this, a quarter of an ounce of indigo is to be reduced to powder, and triturated in a glaſs mortar with two ounces of good oil of vitriol. After this, four ounces of alum are to be diſſolved in warm water, to which muſt be added two ounces of a ſolution of tartar in water, or as much as is requiſite for completing the precipitation. The precipitate is then to be edulcorated and filtered; and when it is almoſt dry, the above-mentioned ſolution of indigo is to be mixed with it. In this manner is obtained a fine blue colour void of all acrimony, which may be mixed with water ad libitum, and with which ſilk, leather and bones may be tinged of different ſhades, and which with ſome gum forms alſo a fine ſap-colour.

SAPONARIÆ OFFICINALIS Lin. Soapwort, bruiſewort; the herb and root.

This grows wild, though not very common, in low wet places, and by the ſides of running waters; a double-flowered ſort is frequent in our gardens. The leaves have a bitter, not agreeable taſte; agitated with water, they raiſe a ſaponaceous froth, which is ſaid to have nearly the ſame effects with ſolutions of ſoap itſelf, in taking out ſpots from clothes, and the like. The roots taſte ſweetiſh and ſomewhat pungent, and have a light ſmell like thoſe of liquorice: digeſted in rectified ſpirit, they yield a ſtrong tincture which loſes nothing of its taſte or flavour in being inſpiſſated to the conſiſtence of an extract. This elegant root has not come much into practice among us, though it promiſes from its ſenſible qualities to be a medicine of conſiderable utility. It is greatly eſteemed by the German phyſicians as an aperient, corroborant, and ſudorific; and preferred by the College of Wirtemberg, Stahl, Neumann, and others, to ſarſaparilla. Lewis.

SAPPHIRE. See Precious Stones, No. 3.

SARCOCOLLA is a gum-reſin, of an ounce of which ſix drams were found to be ſoluble by ſpirit of wine; and ſeven drams and a half were found to be ſoluble by water. Neumann.

SARDONYX. See Precious Stones, No. 20.

SARSAPARILLA. From ſixteen drams of this root Neumann obtained by water ſix drams of gummy extract, and from an equal quantity he obtained by ſpirit four drams of reſinous extract.

SASSAFRAS. The wood of this tree contains the heavieſt of all known eſſential oils. Of this oil Hoffman obtained an ounce and ſix drams from ſix pounds of the wood; and Neumann obtained from an equal quantity of wood, two ounces. From an ounce of ſaſſafras four ſcruples of extract were obtained by means of rectified ſpirit; and from an equal quantity of the wood two drams were extracted by water.

SATURATION. Some ſubſtances unite in all proportions. Such, for example, are acids in general, and ſome other ſalts with water; and many of the metals with each other. But there are likewiſe many ſubſtances which cannot be diſſolved in a fluid, at a ſettled temperature, in any quantity beyond a certain proportion. Thus water will diſſolve only about one fourth of its weight of common ſalt; and if more be added it will remain ſolid. A fluid which holds in ſolution as much of any ſubſtance as it can diſſolve, is ſaid to be ſaturated with it. But ſaturation with one ſubſtance does not deprive the fluid of its power of acting on and diſſolving ſome other bodies, but in many caſes increaſes that power. For example, water ſaturated with ſalt will diſſolve ſugar; and water ſaturated with fixed air will diſſolve iron, though without that addition its action on that metal is ſcarcely perceptible. The word ſaturation is likewiſe uſed in another ſenſe by chemiſts: the union of two principles produces a body whoſe properties are different from thoſe of its component parts, but which reſemble thoſe of the predominating principle. When the principles are in ſuch proportion as that neither may predominate, they are ſaid to be ſaturated with each other; but if otherwiſe, the moſt predominant principle is ſaid to be under-ſaturated, and the other over-ſaturated.

The former kind of ſaturation is remarked in ether with water, eſſential oils with ſpirit of wine, and moſt neutral ſalts with water. If we mix together and agitate good ether with water, a part of the ether unites with the water, nearly in the proportion of one to ten; ſo that if one part of ether be added to ten parts of water, all the ether diſappears by being diffuſed through the water, as the Count de Lauraguais obſerves. If the quantity of ether be more than one tenth part of the water, the overplus will float diſtinct upon the ſurface, like an oil.

Alſo well rectified ſpirit of wine can only diſſolve a determinate quantity of each kind of eſſential oil, which quantity varies according to the kind of oil, and to the ſtate in which it happens to be. In general, the more attenuated they have been by rectification, the more they are removed from a reſinous ſtate, and the ſmaller quantity of them is ſoluble. And alſo the more highly rectified a ſpirit of wine is, the larger quantity of oil it diſſolves.

Water is the proper ſolvent of neutral ſalts. It is capable of diſſolving any of them, but moſt of them only in a certain quantity; and this point of ſaturation of water differs with different ſalts and degrees of heat applied. Macquer takes notice that the point of ſaturation is moſt diſtinct with thoſe ſalts which contain a ſmall quantity only of the water of cryſtallization, and which are nearly equally ſoluble in hot and in cold water. Such are vitriolated tartar, and, ſtill more, common ſalt.

When the water is once ſaturated with theſe kinds of ſalts, the ſtrongeſt and longeſt boiling does not diſſolve a grain more, and the overplus of the ſalt remains entire at the bottom of the boiling water: but boiling water diſſolves an equal or even an unlimited quantity of ſome ſalts, chiefly of thoſe which contain much water in their cryſtallization, ſuch as Glauber's ſalt, alum, borax, martial and cupreous vitriols, and others of that kind. The water of cryſtallization of theſe ſalts is alone ſufficient to keep them diſſolved, by means of heat. Hence, when they are expoſed to fire without water, they ſuffer a liquefaction, which is very different from fuſion, and is nothing elſe than a ſolution of the ſalt in the water of its cryſtallization, and conſequently laſts only till this water be evaporated. The point of ſaturation of water for theſe ſalts ſeems to be indeterminate.

Of thoſe ſubſtances which are capable of uniting without being preciſely ſaturated, the moſt remarkable are, water with the pure acids or alkalis, and ardent ſpirit with moſt of the deliqueſcent ſalts. Such alſo are almoſt all metals uniting with each other: although many of theſe ſubſtances have a great affinity to each other, as the acids and alkalis with water, yet all their general tendency to combination is not exhauſted in theſe kinds of union. On the contrary, in theſe, the laſt-mentioned author thinks that their union is little elſe than a very accurate and intimate mixture. For their diſſolving power is not ſatisfied by ſuch an union, but is almoſt entirely preſerved. We need not therefore be ſurpriſed, that no precise or determinate point of ſaturation is obſerved betwixt theſe ſubſtances. We may ſay, in general, that the point of ſaturation is ſo much more exact, diſtinct, and determinate, as the bodies which unite together have a ſtronger affinity, as they more completely exhauſt upon each other their diſſolving power, or as their relative ſaturation is more nearly equal to their abſolute ſaturation.

The examination of the ſeveral degrees of ſaturation which ſubſtances may ſuſtain by combining together, is an object of great importance in chemiſtry. This matter has been ſcarcely begun, and yet it well deſerves the attention of chemiſts, as it would greatly advance the ſcience.

SATURNITE. By this name Kirwan diſtinguiſhes a ſubſtance ſaid by Monnet to be found in the lead mines of Poullaouwen in Brittany, and ſeparated from the lead ore during its torrefaction. According to him, it reſembles lead in its colour and ſpecific gravity, is ſoluble in the ſame acids, and with the ſame phænomena; but is much more fuſible, very brittle, eaſily ſcorified and volatilized, and refuſes to mix with lead when in fuſion. It were to be wiſhed that it was better examined.

SATYRIUM. Orchidis maſculæ radix. Lin. Orchis: the root.

This plant is frequently in ſhady places and moiſt meadows: each plant has two oval roots, of a whitiſh colour, a viſcid ſweetiſh taſte, and a faint unpleaſant ſmell. They abound with a glutinous ſlimy juice. With regard to their virtues, like other mucilaginous vegetables, they thicken the thin ſerous humours, and defend the ſolids from their acrimony: they have alſo been celebrated, though on no very good foundation, for analeptic and aphrodiſiac virtues; and frequently made uſe of in theſe intentions.

SAUNDERS. The wood of the tree called red ſaunders contains a red colouring material uſed in dyeing. Its colour reſides wholly in a reſinous matter, and hence it is extractable by ſpirit of wine, and not by water. The red colour of ſaunders imparted to ſpirit of wine, becomes, by diluting the tincture with more ſpirit, yellow. The reſin gave a deep red colour to oil of lavender, and a pale red to oil of almonds, and to oil of aniſeeds; but no colour to oil of amber and to oil of turpentine. The wood of the tree called yellow ſaunders is from its fragrance ſometimes employed as a perfume. From ſixteen ounces of the raſped wood, digeſted ſome days in ſalt water, two drams of eſſential oil were obtained by cohobation. Two drams of gummy extract may be obtained from two ounces of the wood by water; and from an equal quantity of wood, two drams and a half of reſinous extract may be obtained by rectified ſpirit. Neumann.

SCAMMONY is a gummy reſinous juice, which exſudes from the root of a ſpecies of convolvulus, in which inciſions are purpoſely made at a certain ſeaſon of the year. An ounce of Smyrna ſcammony yielded with water half an ounce of gummy extract; and the reſiduum yielded with ſpirit two drams of reſin, leaving two drams of impurities undiſſolved. By applying rectified ſpirit at firſt to an ounce of the ſame ſcammony, two drams and two ſcruples of reſinous extract were obtained; and from the reſiduum water extracted half an ounce of gum, the indiſſoluble part amounting here to four ſcruples only. Neumann.

SCORDIUM. An ounce of the dried leaves of ſcordium yielded with water four drams and a half of gummy extract, and afterwards with rectified ſpirit fifteen grains of reſin. Another ounce, treated firſt with ſpirit, gave three drams of reſinous extract, and afterwards with water five ſcruples and a half of gum. A tincture, made in highly rectified ſpirit of wine, contains more of the active and leſs of the mucilaginous parts of this plant, than one made with a weaker ſpirit.

SELENITE. The combination of vitriolic acid and earth. It is plentifully found in nature, and is diſtinguiſhed by the names gypſum, plaſter-ſtone, alabaſter, and gypſeous ſpar, according to its intended uſe or form. It may be produced by adding diluted vitriolic acid to lime, or to a ſolution of the nitrous or marine ſalts with that baſis. This earthy ſalt is one of the leaſt ſoluble we are acquainted with; four or five hundred times its weight of water are required to ſuſpend it. It is the cauſe of the property called hardneſs, in many ſpring waters, by which term it is generally underſtood that the water does not lather with ſoap, nor mitigate thirſt as well as that which is purer. By a moderate heat it loſes its water of cryſtallization, and becomes plaſter of Paris. A ſtrong heat is required to fuſe it alone, but it is more eaſily fuſible in earthy mixtures than pure calcareous earth. See EARTH calcareous.

SEMI-METAL. See METALS.

SENA. Caſſiæ ſennæ Lin. This is a ſhrubby plant cultivated in Perſia, Syria, and Arabia; from whence they are brought, dried, and picked from the ſtalks, to Alexandria in Egypt, and thence imported into Europe. They are of an oblong figure, ſharp-pointed at the ends, about a quarter of an inch broad, and not a full inch in length; of a lively yellowiſh green colour, a faint not very diſagreeable ſmell, and of a nauſeous taſte. Some inferior ſorts are brought from Tripoli and other places; theſe may eaſily be diſtinguiſhed by their being either narrower, longer, and ſharper-pointed; or larger, broader, and round-pointed, with ſmall prominent veins; or large and obtuſe, of a freſh green colour, without any yellow caſt.

An ounce of choice ſena, treated with freſh parcels of rectified ſpirit of wine, afforded Neumann two drams twenty-three grains of reſinous extract; and afterwards with water, two drams two ſcruples of gummy extract, three drams and three grains remaining undiſſolved. Another ounce, treated firſt with water, gave four drams and half a ſcruple of gummy, and afterwards with ſpirit only twenty-eight grains of a reſinous extract, which appeared to contain ſome groſs oily matter, and hence was with difficulty reduced to dryneſs; the reſiduum weighed three drams and a ſcruple.

In diſtillation rectified ſpirit brings over nothing; the diſtilled water is impregnated with the ſmell of the ſena, but diſcovers no appearance of eſſential oil. The activity of the ſena is greatly weakened by evaporation, eſpecially if the proceſs is performed by a boiling heat in an open veſſel, the extract proving far leſs purgative than an equivalent quantity of the infuſion which it was made from. The reſinous extract is more ungrateful in taſte than the watery, and contains the green colour of the leaf.

SENEGAL or SENECA GUM. Gum Senegal, brought from the iſland of that name on the coaſt of Africa, conſiſts of large clear pieces, remarkably tranſparent when broken, and of a contorted appearance on the ſurface. It is ſaid to be uſed as food by the Africans, at leaſt occaſionally, in their travels through the deſerts. It is not thought to differ from gum Arabic, of which it is ſaid to ſupply the place in the ſhops. Gum Senegal is conſidered as one of the ſtrongeſt of gums, and forms a conſiderably thicker or more gelatinous mucilage with water than the reſt. The principal conſumption of this article is among the calico-printers, who uſe it to give thickneſs or body to the ſolutions which they apply to piece goods by means of ſtamps or blocks.

SERPENTINE. Lapis Nephriticus, Gabro of the Italians. In reſpect to colour as well as compoſition, this ſtone is ſuſceptible of great variety; for it is found either white, green, brown, reddiſh brown, yellow, light blue, black, ſpotted, or ſtreaked with veins of different colours. Its texture is either indiſtinct, obſcurely laminar, or fibrous. It is harder than ſoap-rock, but not ſo hard as to give fire with ſteel; and leſs ſmooth to the touch, but ſuſceptible of a good poliſh; looks like marble, and is often in thin pieces ſemi-tranſparent.

Its ſpecific gravity is from 2.4 to 2.65.

It does not effervеſce with acids, but is ſlowly and partially ſoluble in them.

It melts per ſe in a ſtrong heat, and preys on the crucibles. Vogel, 103. In a lower degree of heat it hardens.

According to the analyſis of Mr. Bayen, one hundred parts of it contain about forty-one of ſilex (which he takes rather to be mica), thirty-three of magneſia, ten of argil, twelve of water, and about three of iron. The ſerpentine of Corſica contains a larger proportion of argil and a ſmaller of ſilex.

The greener ſorts of this ſtone have been called nephritic. Their colour ariſes from mangaueſe. But the term Lapis Nephriticus is commonly applied to JADE.

SHOERL, a compound ſtone of the ſiliceous order, more or leſs perfectly united to from 0.46 to 0.83 of its weight of argil, from one fourteenth to one ninth of calcareous earth, and to one fifth or one ſixth of ſemiphlogiſticated calx of iron, and from one forty-eighth to one fifty-eighth of magneſia.

Its diſtinguiſhing properties are, 1ſt, either a ſparry or ſemi-vitrified appearance, like an enamel or a ſlag; 2d, a filamentous or ſcaly texture, which diſtinguiſhes it from garnets; the filaments either ſeparate from each other, or conjoined and plated; 3d, fuſibility per ſe in a moderate heat; 4th, a ſpecific gravity from 3 to 3.6, rarely 4.000, and only when loaded with iron; 5th, its hardneſs nearly equal to that of cryſtal.

According to Kirwan it has two varieties:

I. Tranſparent. This is always cryſtallized in ſome polygonal form: its texture is obſcurely ſparry; its colour brown, reddiſh brown, greeniſh or yellowiſh brown, or violet: its ſpecific gravity from 3 to 3.6.

A reddiſh brown priſmatic ſhoerl of this ſort, from Veſuvius, contained according to Bergman forty-eight per cent. of ſiliceous earth, forty of argil, five of calcareous, one of magneſia, and five of iron. The uſual fluxes affect this ſpecies.

The filamentous ſort reſembles aſbeſtos, and differs externally only in tranſparency, and breaking with an even ſurface.

II. Opake. Theſe are of all colours; white, black, red, brown, greeniſh, and violet: the filaments are conjoined and parallel, or diverge, as from a common center. Thoſe of a ſcaly or ſparry appearance are generally greeniſh or black, and are called hornblende. They are frequently cryſtallized in regular forms, and often ſo ſoft as to be ſcraped with a knife.

An hundred grains of the black cryſtallized ſort from Albano afforded Bergman fifty-eight of ſilex, twenty-ſeven of argil, five of calcareous earth, one of magneſia, and 5 of iron. 3 Berg. 207. Other ſorts have afforded fifty per cent of ſiliceous earth, thirty of argil, one or two of magneſia, and eighteen or twenty of iron.

The white ſort probably contains leſs iron.

All theſe ſorts become reddiſh by calcination.

Bar ſhoerl, Stangen ſchoerl of the Germans, according to Kirwan was lately found in the Carpathian mountains by Mr. Fitchtel, embodied in limeſtone, and cryſtallized in priſms; it ſlightly effervеſces with acids.

According to Mr. Bindheim, one hundred parts of it contain 61.6 of ſiliceous earth, 21.6 of calcareous earth, 6.6 of argil, 5 of magneſia, 1.6 of iron, and 3 of water. 3 Schrift. Naturforſch. Freunde, p. 452.

SIDERITE, a combination of phoſphorus and iron, which is the cauſe of the cold-ſhort quality of iron, into which it enters as a component part. It was firſt mentioned as a peculiar metal by Monnet in his Mineralogy; but it was afterwards more particularly examined by Meyer of Stetin and Bergman, who arrived at nearly the ſame concluſions unknown to each other, but the latter has ſince proved that it is not a peculiar metal, as was ſuppoſed.

Soft iron does not afford it. All the irons of Champagne afford about a dram, or gros, in the pound of iron.

In order to obtain ſiderite, it is neceſſary that the ſolution ſhould be ſaturated by a gentle heat on the ſand bath. If the ſolution be made too quickly, the ſiderite is then mixed with ochre, which alters its purity and whiteneſs.

A precipitate is formed, which takes place ſo much the more ſpeedily, as the ſolution is more diluted with water each time after filtration. The precipitate is formed in the firſt three or four days; a ſecond is obtained towards the ſixth day, and that which afterwards falls down is mixed with ochre.

Siderite may likewiſe be obtained by diſſolving iron in the nitrous acid, and evaporation to dryneſs. The iron is calcined by this firſt operation. More nitrous acid being poured on this reſidue, diſſolves only the ſiderite, without touching the calx of iron. A ſecond evaporation muſt then be made; and the reſidue muſt be diluted with water, to evaporate the laſt portions of nitrous acid; and that which remains is ſiderite. It is ſoluble in the vitriolic, nitrous, and muriatic acids, from which it may be precipitated by pouring into the ſolution as much alkali as is neceſſary to ſaturate the acid ſolvent. If the alkali be added in exceſs, ochre is then precipitated; and the reſult is a phoſphoric ſalt, and a ſalt ariſing from the union of the acid made uſe of, and the alkali which has ſerved for the precipitation.

The fixed and volatile alkalis, and lime water, decompoſe ſiderite. It is likewiſe decompoſed by projecting it upon fuſed nitre.

When it has been precipitated by ammoniac, cryſtals may be obtained by evaporation, which when treated with powder of charcoal afford phoſphorus. The ochreous precipitate affords iron by reduction; it is therefore a combination of the phoſphoric acid and iron. Every ſolution of iron is precipitated in the form of ſiderite by the phoſphoric acid.

SILEX, or SILICEOUS EARTH. See Earth Siliceous, alſo Glass. Under this laſt article I avoided entering into any particular account of the art of glaſs making, on account of the difficulty of obtaining practical information. Since that time a report has appeared in the Annals of Chemiſtry on a work upon that ſubject by Mr. Loyſel, drawn up by thoſe excellent chemiſts Darcet, Fourcroy, and Berthollet, from which, as well for its intrinſic value, as becauſe it is not likely that an Engliſh tranſlation will be made, I ſhall give an extract with very little abridgment.

The art of glaſs-making, as theſe chemiſts obſerve, is peculiarly capable of being ſubjected to philoſophical principles, and conſequently one of thoſe in which the greateſt preciſion might be expected; but to obtain this object it is neceſſary that the obſerver ſhould be no leſs intimately acquainted with all the proceſſes than with the general facts of ſcience. Mr. Loyſel poſſeſſes both theſe qualities. His ſituation and abilities have long induced him to labour in perfecting this art. Whence they conclude that an ample extract of his work cannot but be intereſting to the French Academy.

Vitrification ſuch as takes place in the large way demands two principal conditions: 1. A furnace conſtructed of ſubſtances capable of reſiſting the action of a violent and long-continued fire, and veſſels capable of containing the vitrifiable matter in fuſion without becoming fuſed themſelves. 2. Subſtances which have the property of forming by means of fire a ſolid glaſs, ſuitable to the object of the manufactory.

Of the Furnaces and Crucibles.

The matter employed for the conſtruction of the furnaces and crucibles muſt be of ſuch a nature as to take and preſerve the forms required for the operations of the glaſs-houſe. Clay poſſeſſes this property in the higheſt degree; for which reaſon, though grit-ſtone is uſed in ſome glaſs-houſes, and a mixture of quartz and ſilex with clay, for the conſtruction of furnaces, it has neverthelefs been almoſt generally adopted for the conſtruction of furnaces, and excluſively for that of the veſſels.

Pure clay cannot be fuſed by any degree of heat yet known; but the mixture of other earths, and particularly calcareous earth, cauſes it to enter into fuſion, though itſelf alone be infuſible. Mr. Loyſel reports this important obſervation of Mr. Darcet, which led him to think that the vitrification began with the calcareous earth, acting as a flux to the clay. The reporters mention another explanation of this appearance, by the eminent philoſopher and chemiſt Mr. Delaplace. According to this author, a ſubſtance is infuſible, becauſe its particles remain adherent to each other, and are kept in that ſtate by the force of aggregation which cannot be overcome by the expanſive force of heat; ſo that theſe two forces may be conſidered as oppoſed to each other. If another ſubſtance acts by its electric attraction, upon the particles of that which was infuſible, it then concurs with the action of the heat to effect a diſunion of its particles; and if theſe three forces be repreſented by numbers, it will be required to oppoſe to that number which repreſents the reſiſtance of aggregation, another number conſiſting of the ſum of thoſe which repreſent the action of heat, and the electric attraction of the ſecond ſubſtance. The academicians think it the more neceſſary to inſiſt on this explanation, becauſe it is perfectly agreeable to the laws obſerved in other chemical phenomena. The ancient, but exceptionable adage, "Corpora non agunt niſi ſoluta," cannot be oppoſed to this doctrine, the truth of which is more particularly evinced by the properties of an alloy, pointed out by Mr. Darcet. This metallic mixture enters into fuſion at a degree of heat far below that which is neceſſary to fuſe either of its component parts ſingly. In this caſe then it cannot be that the fuſion of one of the metals favours that of the two others; but their mutual affinity determines the ſeparation of their particles.

The property of reſiſting the moſt extreme heat, is more or leſs altered in clay, by the admixtures it may contain. Sand, quartz, and mica do not prevent a clay from being proper for the uſe of the glaſs-houſe, provided they do not too greatly diminiſh its ductility; but the ſame obſervation does not apply to bituminous matters, calcareous earth, gypſum, pyrites, or the metallic calces. For theſe ſubſtances render it more or leſs fuſible.

The whiteſt clay is generally ſaid to be the moſt refractory; but Mr. Loyſel remarks that whiteneſs is a very equivocal character, becauſe it may conſiſt with a large addition of calcareous earth. Now this earth is hurtful, not only becauſe it renders the clay fuſible, but becauſe it forms pores in the crucibles by the ſwelling it occaſions when its fixed air is diſengaged by the heat. A twentieth part of calcareous earth ſimply renders the compound leſs denſe than clay alone, when expoſed to the fire of the glaſs-houſe; but a tenth part renders it ſenſibly porous.

The choice of a clay in a glaſs manufactory is of ſo much the greater conſequence, as a failure in this article is attended with a loſs of all the expences in fabrication.

The clay to be preferred for this uſe ought to poſſeſs the following qualities: 1. It muſt be ſo refractory, as not to vitrify, or even perceptibly change its figure, by the heat of the furnace. 2. It muſt be ductile enough to receive and retain the requiſite forms. The author deſcribes ſuch trials as are neceſſary to aſcertain theſe two properties.

With regard to the refractory quality Mr. Loyſel propoſes three proofs. In the firſt, after having reduced the clay into ſmall particles, and ſeparated ſuch foreign matters as can be diſtinguiſhed, the application of a mineral acid will ſhew whether it effervesces. If it do, there is reaſon to reject it; but it may be eaſily ſeen that this proof is uncertain.

The ſecond proof conſiſts in working the clay into a paſte with water. Of this paſte, ſeveral priſmatic rods and ſome very thin crucibles of five or ſix inches in diameter, and the ſame height, are to be made. Theſe, after being gently dried, are to be expoſed five or ſix days in the furnace of the glaſs-houſe. The rods muſt be ſuſpended by their extremities on two ſupports. When theſe are taken out, they muſt be put into the annealing furnace, and cooled by inſenſible degrees. If the rods have not bended; if the crucibles have preſerved their figure, and if no cavities be perceived upon breaking them, the clay may be judged to be good.

The third proof which the author prefers to the others, conſiſts in judging the refractory quality of the clay by the action of an alkali upon it. For this purpoſe, it is mixed with different doſes of fixed alkali, in crucibles of the ſame earth, or any other of known goodneſs, and a compariſon is made of the proportion neceſſary to effect a complete vitrification with that which produces the ſame effect in a refractory ſand expoſed to the ſame degree of fire. The author has found, that if eight ounces of alkali be required to vitrify one pound of the ſand of Aumont near Senlies, and ten ounces of the ſame alkali to produce the ſame effect in a like degree of fire, upon a pound of baked clay, this clay may be employed in the conſtruction of furnaces, and crucibles not intended to undergo a more violent heat than that of the proof, provided its firmneſs and tenacity be likewiſe ſufficient.

The eſſay of clays with regard to their tenacity forms the other object of Mr. Loyſel. The ſolidity of works conſtructed with clay depends on the force of the coheſion of its parts. This force, when the work has been dried by degrees to a temperature of 25 or 30 degrees of Reaumur, which correſpond with the 88th and 107th degrees of Fahrenheit, is ſo much the greater in proportion to the ductility of clay when in the ſtate of paſte; ſo that both theſe qualities may be confounded with the tenacity of the clay. But this tenacity is extremely variable. Sand diminiſhes it more than any other foreign admixture.

All the parts of the furnace of fuſion do not require the ſame tenacity. The thicker parts require many cavities for the diſſipation of the moiſture; but the crucibles demand a compact and tenacious clay to reſiſt the fluxes, and oppoſe the preſſure of the glaſs they are to contain. It is of importance therefore to determine the degree of tenacity ſuitable to each object. Of the different methods tried by Mr. Loyſel, the following ſucceeded the beſt:

He forms with the clay intended to be tried, ſmall four-ſided rods, which he leaves to dry at the temperature of 25 degrees of Reaumur. He then faſhions them, and reduces one of their extremities to a dimenſion of ſix lines in each of its four ſides. He inſerts this extremity into a cubical cavity, and at the diſtance of eighteen lines he places the knife edge of a balance, into the baſon of which he pours ſand, until a fracture takes place in that part which is only ſix lines thick; and from the weight of the balance, the ſand, and the broken pieces, he eſtimates the tenacity of the clay. To avoid accidental irregularities, he repeats the experiment with ſeveral of theſe rods. Hence, he finds that his conſtructions are ſolid when the tenacity of the clay prepared for the walls and the arched roof of the furnace of fuſion of eight feet diameter, is ſuch, as to reſiſt about twenty-four ounces applied as here deſcribed; and for crucibles of three feet in diameter, and three inches and a half thick in the lower part, when it reſiſts fifty-ſix ounces. But the degrees of tenacity which may be uſefully applied, have limits of conſiderable extent, and may likewiſe be changed according to the dimenſions of the articles. Thus the reſiſtance of a crucible may be increaſed by adding to its thickneſs.

When it is known by experience what are the thickneſs and tenacity of clay, ſuitable for veſſels of a certain dimenſion, it is eaſy to determine by computation for other dimenſions. The author has given a table for this, viz. the thickneſs of the lower part of the pots, where the preſſure is greateſt, whence the thickneſs diminiſhes to the rim. At this part, though the preſſure vaniſhes, it is nevertheleſs neceſſary, that a certain thickneſs ſhould be given, that it may dry with regularity, and reſiſt ſuch occaſional ſlight blows as the veſſel is likely to receive.

For the moſt part it is not uſual to employ native clay, becauſe it retains moiſture very obſtinately, is apt to crack, and adheres ſtrongly to the moulds. To remedy this inconvenience, its tenacity is diminiſhed, and its poroſity increaſed, by a mixture either of ſand or of baked clay, which is reduced into powder, and improperly called cement. The old crucibles, after a careful ſeparation of ſuch glaſſy matter as may adhere to them, are uſed for this purpoſe; but as theſe do not furniſh a ſufficient quantity, other parcels of clay are baked expreſſly for this uſe.

Sand greatly diminiſhes the tenacity, and is moſt ſtrongly attacked by alkalis. For this reaſon it is uſed only in conſtructions of moderate thickneſs, the reſpective parts of which require only a moderate degree of tenacity to ſupport themſelves. Such are the walls of the furnace of fuſion; but cement is uſed for ſeveral other parts of the furnace, and more eſpecially for the pots.

Glaſs manufacturers differ in their opinions as to the degree of fineneſs proper to be given to the cement; but it is eaſily ſeen that if the cement be more groſsly powdered, the paſte will be leſs homogeneous, more diſpoſed to contract irregularly, and to acquire vacuities into which the fluxes will inſinuate themſelves. It is requiſite therefore, that the cement be reduced to a fine powder, for which purpoſe it muſt be paſſed through very cloſe ſieves of ſilk.

If the tenacity of a mixture of clay and a given quantity of cement be determined, it will be eaſy to aſcertain that of another mixture; for the tenacity of the firſt mixture will be to that of the ſecond, in the ſame proportion as the two quantities of clay with that of the cement.

From ſome inaccuracy in the foregoing paragraph, I confeſs I do not underſtand it. I ſuppoſe the ratio meant to be expreſſed is, that if equal quantities of cement be mixed with unequal quantities of clay, the tenacities will be in proportion to theſe laſt quantities; and again, as no mention is made of any experiments on which this ratio is eſtabliſhed, and as the reaſoning, if any, by which it is deduced does not appear, it ſeems ſafer at all events for the operator to determine his tenacities by experiment with the particular clay he makes uſe of, and tabulate them for future reference.

The author has obſerved, that the proportional tenacities of mixtures determined at a certain degree of heat, continue to be preſerved very nearly at every other degree of heat, provided the tenacity of the clay made uſe of in both mixtures were originally equal.

The contraction which clay undergoes in the fire is ſubject to great variation in different kinds, and deſerves particular attention. Such clays as contract very much, retain water with more force, and are leſs eaſily dried; they ſupport the alternations of heat and cold more difficultly; become filled with cracks and clefts, through which the fuſible matters penetrate, and appear on the outſide in vitrified exſudations. This laſt inconvenience is more particularly to be feared in ſuch glaſs works where the pots remain uncovered, as is the caſe where wood, and not pit-coal, is the fuel. For then the glaſs which drops from the roof, mixes with the vitrified matter, and produces ſpots (larmes) and veins.

Cement and ſand diminiſh the contraction of clay in proportion to their quantity; but at the ſame time they diminiſh its tenacity, and by rendering it more porous cauſe it to be more eaſily vitrified by the fluxes. The maſter of the glaſs work muſt determine what mixture is moſt ſuitable to his undertaking, by combining theſe different properties. If he uſes covered veſſels, he may employ a much greater proportion of ſand or cement in the roof of his furnace. There are ſome who prefer ſand to cement; but a diſtinction muſt be made as to the degree of fuſibility in the clay made uſe of; for if the cement have more fuſibility than the ſand, as will happen with clays of middling quality, the ſand ſhould then undoubtedly be preferred; but with a good clay, the cement is certainly beſt.

Concerning the Conſtruction of the Furnaces for Fuſion.

There are three methods of conſtructing the furnace of fuſion in a glaſs-houſe. 1. By uſing ſoft bricks. 2. By uſing bricks dried at the ordinary temperature of the atmoſphere. And 3. By uſing bricks baked in the uſual heat of a brick-kiln.

The ſoft bricks are made as follows: The clay is firſt dried, and the foreign matters which can be diſcerned are taken out, for which purpoſe the pieces muſt be broken, and examined within. This operation is called in French l'epluchage de la terre. If the clay contains much pyrites, the earth is mixed with water, in ſuch a quantity that the maſs may be paſſed through the common ſieve of the mealman. The larger pyrites remain behind, and thoſe which come through ſubſide to the bottom with the coarſer ſand. The mixture is then left to reſt, the earth gradually ſubſides, and the water is from time to time drawn off, by cocks at different heights in the ſide of the veſſel, until the mixture is ſufficiently thick to be worked up with the ſand or cement. This operation laſts between two and three months; at the end of which time, the matter, rejecting the inferior or lower part, is mixed with the ſand or cement into a proper paſte. If the clay do not contain pyrites, it is ground without water in a mill under a millſtone of grit, then ſifted and mixed with the ſand or cement. Water is then added to convert the whole into a paſte; or otherwiſe the clay purified by the firſt proceſs of examination is ſoaked with water for four-and-twenty hours, and mixed with ſand or cement.

In whatever manner the paſte may have been prepared, it muſt be of ſuch a conſiſtence, that a ball of lead weighing four ounces may bury itſelf the depth of its diameter, when let fall out of the hand from an height not leſs than twenty-four inches, nor more than forty-five.

In this ſtate the bricks would be too ſoft for the conſtruction of a furnace, and would contract too much in drying. It is neceſſary therefore, that they be left to dry upon planks of wood. The firmer they are, the better for uſe, provided they do not break under the mallet of the workman, who ſtrikes them with all his force to unite the different courſes together, and to give them the figure required in the different parts of the arch-work. In this ſtate a ball of lead of four ounces will require not leſs than a height of twenty-five feet, nor more than thirty-five, to bury itſelf half its diameter in the clay; but a conſideration of importance is, that all the bricks ought to be ſenſibly of the ſame conſiſtence, in order that the contraction of the different parts of the furnace may be as equal as poſſible.

The academicians paſs over for the ſake of brevity the detail into which the author enters, of the method of conſtructing furnaces with theſe bricks, and the ſingular precautions required in their drying.

This method of conſtruction is the beſt which is known in the glaſs works. It is attended with the feweſt cracks, and endures the longeſt. It is particularly advantageous in the manufactories of fine glaſs, and thoſe wherein the veſſels are uncovered. Neverthele ſs it is uſed only in great eſtabliſhments. The reaſon is, that this conſtruction requires more care, time, and expence than any other. It requires likewiſe a building, in which there are no other furnaces at work, in order that the drying may not be too haſty.

The conſtruction with bricks dried in the air, or baked in the ordinary method, has nothing peculiar in it. This method of building ought to be reſerved for glaſs works where the pots are covered, or for common glaſs. And even in theſe, the firſt method would be found the moſt advantageous, if the neceſſary capital be not wanted.

Concerning the Fabrication of the Veſſels or Crucibles.

The paſte or mixture of clay and cement is prepared in the ſame manner as for the bricks already deſcribed, with this difference only, that it muſt be more conſiſtent. A ball of lead of four ounces weight ought not to fall from a leſs height than ſixty-five inches, nor a greater than eighty-three, to bury itſelf beneath the ſurface.

There are two methods of making pots for the glaſs-houſe. In the firſt, a mould of wood is made uſe of, lined within with a ſtrong and well ſtretched cloth, and rolls of the paſte are applied ſucceſſively one above the other. In the ſecond method a potter conducts his work without a mould, and joins the rolls of clay together by preſſing them ſtrongly between his hands. This ſecond method is conſidered as better and more exact than the firſt.

The drying of the pots muſt be effected in the ſhade, in a place defended from currents of air, in a temperature of between 10 and 15 degrees of Reaumur, which correſpond to the 55th and 65th degrees of Fahrenheit nearly. The drying muſt be ſlow, in order that the contraction may be regularly made. It is likewiſe requiſite to defend them from froſt and dampneſs. For this purpoſe, when the pots begin to dry, they are put into a cloſe place, where the heat is gradually raiſed to 25 or 30 degrees. They are then conveyed into the oven called *arche*, which I take to be the annealing furnace above the roof of the furnace of fuſion. There they are gradually heated to ignition; after which they are put into the melting furnace, heated leſs than its uſual rate. The fire is ſucceſſively raiſed to its greateſt degree of heat. In large works, this diminution of the heat laſts three or four hours; but this time is not ſufficient to effect a complete drying, for pots of large dimenſions. Theſe are uſually left empty during the firſt working of the other pots.

Concerning the Heat of the Furnaces of a Glaſs-houſe.

Mr. Loyſel eſtabliſhes with much care the principles, for which we are indebted to modern chemiſtry, of combuſtion and the communication of heat, to infer ſuch diſpoſitions as may be moſt advantageous for the conſtruction of furnaces and management of the fire.

The heat is greater the larger the quantity of air conſumed. The entrance of the furnace ought to be therefore entirely free for the acceſs of air; and the vapours of the furnace, which conſiſt in a great meaſure of air unfit to maintain combuſtion, ought to be carried off as much as poſſible. Hence it follows, that the method employed in glaſs works where pit-coal is the fuel, and in a few others where wood is uſed, deſerves approbation. It conſiſts in eſtabliſhing a current of air through one or more arched paſſages, commonly under ground, one of the extremities abutting at the furnace, and the other being placed without the building which contains the furnace, and is commonly called the hall. By this means, ſeveral furnaces of fuſion may be placed in ſucceſſion in the ſame hall, without the combuſtion of the one being injurious to that of the other, as uſually happens in leſs judicious arrangements. That diſpoſition which approaches neareſt to this, is when the doors of the hall are oppoſite the furnaces; but the moſt injudicious is that which is commonly employed in glaſs works where wood is burned. In this, the doors of the hall are on one ſide. The time required for the fuſion and depuration may vary by the difference between the firſt and the laſt diſpoſition from 18 to 34 hours.

The air ought to be heated before it arrives at the fire, that its temperature may be leſs remote from that wherein the combuſtion is effected. It ought therefore to paſs through the aſh-hole. Ordinarily in furnaces wherein wood is burned, the current is directed againſt a ſmall dome above the aſh-hole. It ought to be directed immediately into the furnace.

The interior part of the furnace cannot acquire its greateſt degree of heat, but in proportion as that which is produced in the fire is deprived of the liberty of eſcaping during its diſengagement. It is even neceſſary that it ſhould be diſtributed as equally as poſſible through the whole interior capacity of the furnace. Now this effect depends on the magnitude and poſition of the iſſues of the flame, and the interior figure of the furnace.

It is eaſy to aſcertain by experience in each particular caſe the proportion which ought to exiſt between the entrance of the air, and the eſcape of the flame, by making the apertures of that eſcape at firſt larger than neceſſary, and then diminiſhing them with moveable bricks diſpoſed for this purpoſe, until the furnace appears to be in the greateſt ſtate of ignition.

The heat is greateſt in thoſe parts where the motion of the flame is the moſt rapid, and this is uſually in the vicinity of thoſe apertures to which it is naturally directed. The equality of the heat of the pots placed round the furnace depends therefore on an equal diſtribution of the apertures round the ſame circumference.

The internal figure of the furnace likewiſe ſenſibly influences the motion of the flame, and conſequently the degree of heat thence ariſing, as well as the equality of its diſtribution in the different parts of its capacity. The horizontal ſection of moſt of the glaſs-houſe furnaces, in France, is a ſquare or rectangular parallelogram in the whole of the part occupied by the pots. Hence it ariſes that the motion of the flame is checked in the vicinity of the pots placed in the angles; that the heat is leſs in thoſe than in the other pots, and conſequently that with equal mixtures of vitrifiable matter, the glaſs is not ſo well refined in the ſame time as in the other pots, and a greater degree of heat muſt be uſed to accompliſh this purpoſe. This produces, 1. a greater expence of fuel; 2. the vitrification and deſtruction of the dome by exceſs of heat; and 3. the dome being very much heated, it is neceſſary that the fire ſhould be ſlackened in order that the glaſs may clear itſelf before the work commences. Mr. Loyſel therefore propoſes that the figure of the furnace ſhould be changed, and that it ſhould be formed of a continued curve line like the dome.

The vault or dome of the furnace is the part to which artiſts pay the greateſt attention. Its figure is not the ſame in all glaſs-houſes; but in a conſiderable number its generating curve more or leſs approaches the common parabola. Mr. Loyſel proves from various conſiderations, that the ſpherical figure is more advantageous.

Pit coal and wood are equally capable of affording heat not only ſufficient for vitrification, but even to alter the figure of the pots. The flame may be more or leſs charged with ſooty matter, which is hurtful in all caſes wherein the flame comes in contact with the glaſs. It colours the vitrifiable matter, and reduces the metallic calces, if ſuch enter into the compoſition. There are caſes wherein the intenſity of the heat and the purity of the flame are equally eſſential, as in the fabrication of glaſs, where the manipulations require the pots to be uncovered. In other caſes the intenſity of the heat is the principal condition, as in the glaſs-works where the pots are covered. In other circumſtances again, the purity of the flame requires the utmoſt conſideration, as in the calcination of the frit.

If the colour of the glaſs be a matter of no conſequence, pit coal may be uſed for all the operations, provided that the metallic calces do not enter into the compoſition; but if an equally quick fuſion be required, with ſimilar doſes of fluxing-matter in covered as in uncovered pots, a greater heat muſt be applied, on account of the reſiſtance oppoſed to the tranſmiſſion of the heat by the cover.

Reſinous woods afford more ſmoke than poplars, aſh, &c. and theſe more than birch, oak, ſycamore, and beech. The three laſt are the beſt for heating the melting furnaces; as well for the purity of the flame, as the intenſity of the heat.

In order to obtain the greateſt quantity of flame, and the leaſt of ſmoke, the ſame quantity of fuel muſt be conſtantly kept on the fire. It muſt therefore be added in ſmall quantities, and at frequent intervals.

It has already been mentioned that Mr. Loyſel, in order to determine the tenacity of different mixtures of clay and cement, and of clay and ſand, made uſe of rods of clay, each face of which was ſix lines broad; that theſe rods were dried in the ſame degree of heat, and afterwards broken by weights ſuſpended at the diſtance of eighteen lines from the plane of fracture. The author has made experiments to aſcertain the proportions of tenacity acquired with the different degrees of heat to which the clay was expoſed. With this view he prepared a great number of rods with the ſame clay, and in each experiment he baked at leaſt four or five in the ſame degree of heat, to exclude thoſe of which the reſults might be too diſcordant, on account of inequality or the variable poroſity of the materials.

In this manner Mr. Loyſel made ſix experiments from 17 degrees of the thermometer of Reaumur, as far as 234; after which having conſtructed a curve whoſe ordinates repreſent the degrees of temperature, and the abſciſſæ the weights neceſſary to break the rods, he found that this curve did not ſenſibly differ from the parabola; and from the equation of this curve, he determines a law between the degrees of temperature and the weights neceſſary for the fracture.

The degrees of heat which he found immediately by the thermometer, or by the preceding rule, are as follows:

The heat of the apartments in which the unbaked pots are kept ought not to be leſs than 25 degrees, and ſometimes riſes as high as 40; that of the *arche* ought not to be higher than this, when the unbaked pots are introduced: it is gradually increaſed during eight days. At this period the proof of the rods indicated between 900 and 1000 degrees. The loweſt heat of a great melting furnace proved to be about 8000 degrees. The moſt uſual heat is about ten or eleven thouſand degrees, and ought not to exceed fourteen or fifteen thouſand degrees, becauſe at this laſt temperature, pots of two feet diameter within, and three inches and a half thick, made of good clay, are broken by the preſſure of twenty-five inches in depth of glaſs.

It may be obſerved that Mr. Loyſel has availed himſelf of a different property from that uſed by Wedgwood. See PYROMETER. The firſt has choſen the tenacity, and the ſecond the contraction of clay, to determine the degree of heat. The ſecond method, as the academicians obſerve, requires leſs apparatus; to which we may add, that it appears to depend leſs on arbitrary dimenſions, and indicates minuter differences in leſs time. But theſe reporters juſtly queſtion whether the one or the other method be adequate to prolong the graduation of our thermometers. The heat at which it was poſſible for Mr. Loyſel to make his comparative experiments, extended no further than from 17 degrees to 234 of Reaumur; a ſpace much too contracted to eſtabliſh a progreſſion to the extent of 14,000 degrees. As to the agreement of theſe two methods, Wedgwood (ſee page 748) remarks that there are three heats in the glaſs furnaces; a ſtrong heat for vitrification, a low heat for ſettling, and a greater called the working heat. This laſt was found in plate glaſs to be 57° of his thermometer, which we may ſuppoſe to correſpond with conſiderable latitude to the ordinary heat of Mr. Loyſel juſt mentioned. Now Mr. Loyſel's ordinary heat, reduced to the ſcale of Fahrenheit, is 23407°, and the working heat of Wedgwood, according to the ſame ſcale, is 9165°; a difference apparently too great to be admitted without the ſuppoſition of error in the parabolic curve of the former, the ſhort intermediate ſcale of the latter, or, which is ſtill more probable, a change in the meaſuring property of the clay, at the higher temperatures. It muſt not however be overlooked, that the heats uſed in the glaſs furnaces, and elſewhere, for the ſame nominal purpoſes, were found by Wedgwood to differ extremely, though not ſo much as the preceding numbers do from each other.

Concerning the Vitrification and Vitrifiable Matters.

The author here deſcribes the ſiliceous earth diſtinguiſhed by the name of vitrifiable, and enumerates the metallic and ſaline fluxes, of which he gives an account in the following articles. It was obviouſly unneceſſary for the academicians to follow the author in thoſe chemical departments which his plan required him to explain, and accordingly their extract is very properly confined to ſuch parts as are peculiar to the art of glaſs-making.

Of the Choice of Vitrifiable Earth.

The whiteſt ſand is the moſt frequently mixed with other earthy ſubſtances. To clear it of theſe, it is waſhed with agitation in clean water. The earthy parts, which are lighter than the ſand, remain ſuſpended in the water, which is decanted off, and freſh parcels added till it comes off clear. If it contains combuſtible matters capable of colouring the glaſs, it is ignited for the purpoſe of burning them off. This is the method of purifying the ſand for fine glaſs.

Of the Metallic Calces conſidered as Fluxes.

Of all the metallic calces conſidered as fluxes of ſiliceous earth, thoſe of lead are the moſt uſed; not only becauſe they are capable of vitrifying a larger doſe of this earth, but becauſe they are leſs coſtly, and may be employed in conſiderable proportions without injuring the whiteneſs of the glaſs. Minium is preferred to any other calx of lead. If it be uſed with the vitrifiable earth of pulverized flints, or the white ſand of Aumont near Senlis, five pounds of minium cannot completely vitrify more than two pounds of this earth in the ordinary fire of the glaſs-houſe. The glaſs which reſults is of an orange yellow, and full of veins; and ſpecifically near five times as heavy as water. If the doſe of earth be ſmaller, the vitrification is more ſpeedy, and the glaſs is more coloured and heavy. The greater proportion of calx of lead which enters into a compoſition, the leſs brittle the glaſs proves by the alternations of heat and cold. The more on the other hand the vitrifiable earth predominates, the glaſs will be more white, tranſparent, light, ſubject to break by ſudden change of temperature, and difficult to ſoften by heat. The proportions of calx of lead and ſand muſt therefore be varied according to the object deſired.

Concerning Arſenic.

The uſe of arſenic is avoided in glaſſes which contain calx of lead, becauſe this material favours its ſublimation. The moſt effectual, as well as the moſt common method, is to mix nitre along with the vitrifiable materials. A large doſe of arſenic gives a milky appearance to glaſs, and may even render it entirely opake. As glaſs is ſometimes capable of being attacked by acids, it is proper to avoid arſenic in all veſſels intended to contain liquors for drinking.

Arſenic mixed with coaly matter and expoſed to the fire becomes violently inflamed and flies off. Advantage has been taken of this property: when it is perceived during the fuſion that the glaſs is coloured yellow for want of calcination, and that the maſs is not ſufficiently fluid, ſome manufacturers are in the habit of throwing pieces of arſenic into the pot. The arſenic takes away ſome of the colour from the glaſs, and by its inflammation and volatilization gives to the maſs an internal movement, which facilitates its ſettling, and partly clears it of bubbles. But it is evident that it is uſeful only as a remedy for preceding negligence. Mr. Loyſel is of opinion that arſenic may and ought to be baniſhed from the glaſs-houſe.

Concerning Saline Fluxes.

The pot-aſh and ſoda employed as ſaline fluxes vary conſiderably by the quantity of earth and neutral ſalt they contain. For common glaſſes the mere aſhes are frequently uſed. In all caſes trial is made in the ſmall way of the beſt proportions of the ſand and the alkali.

The neutral ſalts which are mixed with the alkali are not only hurtful becauſe they diminiſh the proportion of this laſt, but principally becauſe they are incapable of combining with vitrifiable earth, and when mixed through the whole maſs of the glaſs, they form a foreign opake matter. In this ſtate the moſt active and long continued heat would be ſcarcely ſufficient to diſſipate theſe ſalts. The moſt effectual remedy hitherto diſcovered conſiſts in diminiſhing the heat of the furnace when the time of complete fuſion is paſt. The neutral ſalts being ſpecifically lighter riſe to the ſurface, where they are taken off, and form what is called ſandiver, ſalt of glaſs, or glaſs gall; but this operation is attended with a loſs of time which is of prejudice, and ſome of the ſalt may remain in the manufacture. It is uſually ſeen in the form of white flowers reſembling flakes of ſnow. Theſe kinds of glaſs are brittle, eſpecially when part of the ſalt of glaſs is at the ſurface. It would therefore be a valuable operation to deprive the alkalis of the neutral ſalts with which they are mixed. Mr. Loyſel avails himſelf, for the purification of pot-aſh, of its property of being much more abundantly ſoluble in water than the neutral ſalts it may contain. One hundred pounds of the ſaturated ſolution of fixed vegetable alkali contain forty-eight or fifty pounds of alkali; and this ſolution makes forty-eight or fifty degrees on the areometer of Baumé. If the evaporation be carried on till the ſolution is concentrated to the fortieth degree, the greateſt part of the foreign ſalts ſeparate, and what remains cannot injure the glaſs. This method adds very little to the expence, becauſe the beſt manufacturers are in the practice of diſſolving their potaſh to ſeparate its impurities.

During the fuſion the fixed air is diſengaged from the alkali, and produces an effervеſcence which renders it neceſſary to increaſe the number of fuſions; adding but ſmall quantities of the mixture at a time, in order that the elaſtic fluid may be at liberty to eſcape. By this means the time of fuſion is prolonged. The inconveniences of this effervеſcence are avoided by adding, as Mr. Loyſel propoſes, an equal weight of lime to the alkali, in the ſolution made for the laſt-mentioned purpoſe. This cauſtic alkali is very deliqueſcent, but it may without any inconvenience be employed in the glaſs-works immediately after its deſiccation.

Pure alkali diſſolves a quantity of vitrifiable earth, which is more conſiderable the greater the intenſity of the heat: ſo that the point of ſaturation depends on this circumſtance. Whence it happens that the glaſs made at different furnaces is more or leſs alkaline, and conſequently more or leſs ſubject to decompoſition. If the proportion be ſuch, that the alkali in the glaſs be leſs than one fourth of its weight, the glaſs will be very ſolid: but if the heat made uſe of be ſo feeble that the point of ſaturation cannot be obtained but by the proportion of equal parts of theſe two ingredients, the glaſs, though clear and tranſparent, will be of ſo looſe a compoſition as to be attacked and diſſolved by mere water.

Concerning Lime.

Calcareous earth renders the glaſs into which it enters leſs ſubject to attract moiſture, and leſs brittle by changes of heat and cold. Its whiteneſs is not perceptibly altered; but in order to avoid the effervеſcence produced by the diſengagement of fixed air, the common practice is to uſe lime. This practice is ſtill more advantageous, becauſe the combuſtible matters of the lime ſtone are burned by calcination; and the water, which is one of its component parts, is diſſipated. This water, together with the fixed air, if volatilized in the furnace of fuſion, would facilitate the eſcape of part of the alkali.

Vegetable earth, ſuch as is obtained by lixiviation of the aſhes of vegetables, is uſed only for the moſt ordinary glaſs, becauſe it alters their clear white colour. As it is fuſible alone, which lime is not, it might be employed in large doſes without fear of impeding the vitrification of the ſand and alkali, if there were not cauſe to fear the deſtruction of the pots, which it very ſpeedily corrodes. This property makes it neceſſary to limit its proportion to one pound for every two pounds of ſand, and a ſufficient quantity of alkali.

The lime demands for its vitrification a greater quantity of alkali than ſand does; yet the doſes of ſand and alkali being determined for the vitrification, a good glaſs may be obtained by adding a certain quantity of lime. Whence it happens, that with the ſame quantity of flux a large quantity of glaſs is afforded, without conſidering the good qualities the lime communicates. Lime cannot, however, be uſed but with great moderation, becauſe the glaſs of which it is a part vitrifies the clay of the pots, of which the preſervation is an important object. From this conſideration no more than ten or fifteen pounds of lime are added to one hundred pounds of alkali, and two hundred or two hundred and twenty pounds of vitrifiable earth.

There is an eaſy remedy againſt the action of the glaſs containing calcareous earth upon the pots. It conſiſts in adding to the compoſition of the glaſs a ſufficient quantity of clay to effect a ſaturation. This is accordingly done in the manufacture of bottles. But as the clay uſed in the glaſs-houſes always produces a green glaſs, it cannot be admitted in the compoſition of the white glaſs.

A very remarkable effect of calcareous earth, and alſo of the vegetable earth, in vitrification, is the decompoſition of the vitriolic ſalts with baſes of fixed alkali, whatever may be the manner of their favouring the diſengagement of the acid. Calcareous earth may be vitrified in the proportion of one part of the earth to three or four of ſalt, according to the degree of the fire. This property renders the uſe of lime and the vegetable earth very advantageous in the manufactories of common glaſſes, wherein the ſoda of varec is uſed, which contains a conſiderable proportion of Glauber's ſalt or vitriolated ſoda.

Concerning the Subſtances proper to purify the Glaſs.

The ſubſtances moſt advantageouſly employed in the purification of glaſs are the calx of arſenic, nitre, and the calx of manganeſe. The firſt has been already mentioned.

Nitre ſerves as a flux by virtue of its alkaline part, and may ſupply the place of alkali according to the proportion it contains; but its high price prevents its being employed for that purpoſe. It is with a view to deſtroy the coaly matters contained in the mixture that it is added, and accordingly it is never uſed but when the materials have not been enough calcined.

It is likewiſe with the ſame view that the calx of manganeſe is uſed. We are indebted to Scheele for a knowledge of the manner in which this calx operates. Naturally it gives a violet red colour to glaſs; but when deprived of part of its oxigene or vital air by the combuſtion of coaly matter, it loſes its colour and leaves the glaſs white. Hence a notion may be formed of its effects when added to glaſs in different proportions. If the doſe be too ſmall, it does not deſtroy entirely the yellow colour produced by the coal of the ingredients not ſufficiently calcined; if it be too large, it communicates its own peculiar tinge.

The calx of manganeſe is capable of deſtroying ſuch colours only as are produced by coaly matter; but not that which ariſes from metallic ſubſtances, ſuch as iron, lead, and cobalt. In theſe caſes it produces a mixed colour from the combination of its own tinge and that of the metal already in the glaſs.

If it be propoſed to communicate to glaſs the colour of the calx of manganeſe, the materials muſt be well calcined; and arſenic muſt not be uſed, as it would attract the vital air of the calx. Nitre will reſtore the colour if deſtroyed. It effects this by affording vital air.

In ſome caſes, when it is deſirable to give a ſlight green tinge to glaſs, inſtead of the yellow colour produced by a metallic calx, a ſmall quantity of the calx of cobalt is added, which gives a blue colour, and this by mixture with the yellow produces a green.

The calx of manganeſe forms a glaſs ſpecifically heavier than common glaſs; whence it ariſes that the glaſs at the bottom of the pots in many glaſs works is violet. It is undoubted that when this happens the doſe of manganeſe is too great. The uſual method of remedying this inconvenience is to ſtir up the glaſs with an iron bar, after previouſly raiſing the fire to render it more fluid. It is thought that the manganeſe is in part diſſipated by that means; but it is merely diſtributed through the maſs. A more effectual remedy is to add ſome combuſtible ſubſtance to the glaſs to deſtroy its colour; ſuch as arſenic, charcoal, ſulphur, &c.

Concerning the Calcination of the Vitrifiable Matters.

The calcination is an important preparation of the materials intended to be vitrified. Its chief effects are the diſſipation of volatile ſubſtances, which ought not to enter as conſtituent parts of the glaſs, and the combuſtion of coaly matters, which without this operation never fail to colour the glaſs.

Two conditions are requiſite to a perfect calcination: 1. the materials muſt preſent a large ſurface to the air; and 2. the heat to which they are expoſed ought not to be attended with the ſmoke of the fuel. The firſt condition demands that the heat ſhould not be ſo violent as to produce fuſion. And moreover the heat ſhould be gradually raiſed, to drive off the volatile matters, without raiſing along with them any part of thoſe which are more fixed.

The ſand made uſe of is commonly more or leſs white in its natural ſtate; but it becomes ſtill more ſo by calcination, and the glaſs is improved in conſequence. The fire may be urged to the ſtrongeſt degree when ſand is calcined by itſelf; but a moderate heat is commonly uſed, unleſs when the very fineſt glaſs is intended to be made. In general the ſand is ſubjected to no other calcination than that of the mixture of alkali, lime, &c. called the frit.

The calcination of the alkali is of the firſt importance. By this means the elaſtic fluid is driven off which would diſturb the fuſion. Part of the evaporation of the ſalt, which takes place before it acts as a ſolvent to the ſand, is thus prevented. And more particularly the coaly matters are burned, which it always retains notwithſtanding any other previous depuration.

In the purification of alkalis all ſuch veſſels are to be avoided as might communicate colouring particles to them; ſuch as boilers of iron. Thoſe of lead are preferable; becauſe if any portions of the metal ſhould be detached, no ſenſible inconvenience will ariſe as to the whiteneſs of the glaſs.

The heat muſt be more particularly attended to in the purification of the alkali, that it may be ſo moderate as not to produce that liquefaction which is called the aqueous fuſion, and ariſes from the water it contains. For this purpoſe the ſalt muſt be frequently turned, and not calcined in too great a quantity at a time.

The calcined fixed alkali may be preſerved in its concrete form in apartments defended from moiſture. The ſame precaution is not required for the lime and ſand.

After the mixture of theſe three ſubſtances the mixture may be ſubjected to vitrification in the pots of the furnace of fuſion; or it may be ſubjected to another calcination called the operation of the frit. If the mixture of vitrifiable matters be not ſubjected to this operation, the other ingredients are likewiſe added at this period, whether they be nitre, arſenic, or calx of mangaueſe, for purifying the glaſs, or ſuch metallic calces as are intended to produce colour. But if the mixture be fritted, no other materials are now added but the calces which are intended to poſſeſs the laſt ſtate of calcination.

Concerning the Operation of the Frit.

The operation of the frit anſwers two purpoſes. The firſt is to complete the combuſtion of the coaly matter and the diſſipation of volatile ſubſtances; the ſecond, to incorporate the materials with each other by a beginning of that combination which is perfected in the furnace of fuſion.

When a mixture of very dry concrete alkali and ſand is made, and immediately ſubjected to an heat ſufficient for its vitrification, the alkali ſpeedily enters into fuſion; the ſand being more heavy than this fluid alkali, falls to the bottom of the veſſel, and the ſupernatant alkali is in part evaporated before the whole of the ſand can be diſſolved. In this caſe the glaſs will contain unvitrified ſand, notwithſtanding a ſufficient or even ſuperabundant proportion of alkali may have been uſed. This inconvenience is but too common in thoſe works where the operation of the frit is not uſed; but it is avoided by that commencement of union which the ſand, lime, and alkali acquire in this operation, and which holds them together till the vitrification is completed.

The accurate mixture of the vitrifiable matters can alone produce the cleareſt glaſs, which is the propereſt to receive the ſeveral colours afforded by the metallic calces. The frit is therefore an operation of advantage for coloured glaſſes, as it prevents the production of falſe or irregular tinges.

Vitrifiable matters newly fritted deſtroy and corrode the crucibles leſs than ſuch as have not been ſo treated: 1. becauſe they are exempt from humidity: and 2. becauſe the alkali is no longer in a diſengaged ſtate.

When it is propoſed to augment the denſity of a glaſs by means of a metallic calx or glaſs, ſuch as thoſe of lead, the glaſs produced will be more uniform in its texture, the more equally the combination has been effected through the whole of the maſs. Now the commencement of combination, which is eſtabliſhed between all the parts of the frit, prevents the calx of lead from falling down as readily as it would otherwiſe do.

The operation of fritting is performed in one or more furnaces adjacent to the furnace of fuſion which communicates with it, and to which the name of *arches à fritte* is given by the French, or otherwiſe it is done in ſeparate furnaces. The former method is preferable, becauſe the flame does not arrive at the frit until all the parts of the fuel have had time to be conſumed; becauſe they can more eaſily be kept at a ſteady and ſuitable heat without an additional expence of fuel, and becauſe the vitrifiable matters may be immediately transferred in their white heat to the furnace of fuſion. Hence the vitrification is more ſpeedy, and the crucibles leſs injured, than if the materials were put in cold.

Concerning the Fuſion of the vitrifiable Matters.

It is neceſſary to diminiſh the heat of the furnace at the time of working the glaſs, in order that it may aſſume conſiſtence enough to be wrought; but as the ingredients required to be added from time to time occaſion a refrigeration, the furnace is again heated before they are introduced. The time of re-heating differs in different works: but it is ordinarily one or two hours for furnaces of ſix or ſeven feet in diameter.

The cold produced by this circumſtance being in proportion to the quantity added, it is clearly requiſite not to add too much at a time; becauſe too much cooling might even break the veſſels. The pots are therefore filled at two, three, or four different intervals; and this is called making two, three, or four fonts (*fontes*).

The ſecond font muſt not ſucceed the firſt until the preceding vitrification is completed. Two methods are uſed to aſcertain this. The firſt conſiſts in obſerving the end of the effervefcence, and the diſſipation of the alkali ſuperabundant to the vitrification; which may be known by the tranquillity of the font. The ſecond conſiſts in taking proof of the glaſs, after the ceſſation of the fumes ariſing from the evaporation of the alkali. If it be found that the bubbles are diſſipated, the ſecond font may be made: and the ſame obſervation applies to the ſucceeding fonts.

The time employed in the vitrification is diſtinguiſhed by the name of the time of fonding, and that employed in the diſſipation of the bubbles, the ſettling or refining (affinage). The glaſs is ſaid to be fine, or well refined, when it contains no more bubbles. If the ſecond font were to be made before the glaſs of the firſt were well refined, the ſubſequent cooling would prevent the diſſipation of the bubbles, at leaſt during the whole time requiſite to produce the original fluidity, and the ſubſequent refining would prove long and tedious. While the pots are thus ſupplied, the vents of the flame muſt neceſſarily be kept open, which cools the furnace alſo. For theſe reaſons, it is proper to avoid either too few, or too many fonts.

As ſoon as the glaſs is fine, the heat of the furnace is diminiſhed by adding leſs fuel, or none at all, according to the nature of the work, whether of blown or of caſt glaſs. By the diminution of heat, the glaſs becomes thicker or leſs fluid, and is fit for working. During the whole time of working the conſiſtence muſt be the ſame: and for this reaſon, in the operation of blowing, of which the working may continue from five hours to twenty or more, according to the nature of the articles, the furnace muſt be kept at the ſame degree. But this need not be as intenſe as for the fonding and refining.

This laſt remark does not quite agree with the account given by Mr. Wedgwood (Art. Pyrometer, p. 748) of the fonding, ſettling and working heats. But I ſuppoſe the working heat to be, as Mr. Loyſel informs us, lower than the others for blown glaſs; and that Mr. Wedgwood's increaſed heat for working may be uſed only in the manufacture of *caſt* plate glaſs.

There are two methods in practice of conducting the fonding, refining, and working of glaſs. In the firſt, each operation is made at the ſame time in all the pots; in the ſecond, the fonding and refining are effected in one half of the pots, while the glaſs is worked in the others. It is eaſy to imagine that the glaſs works where this laſt practice prevails cannot have ſo intenſe a fire as the others. To ſupply this defect, a greater quantity of flux is uſed in the vitrification; and the glaſs, containing leſs earth, is tender, and ſubject to be decompoſed. Exception muſt however be made with regard to thoſe glaſs works in which no other materials are uſed but old glaſs, or very fuſible matters, ſuch as lavas, baſaltes, &c.

Of the Annealing of Glaſs.

Glaſſes of any conſiderable thickneſs, as for example two or three lines, if ſuffered to cool in the open air immediately after being formed, ſuffer an unequal contraction from their ſurface on account of the inequality of their thickneſs. Theſe glaſſes frequently break of themſelves by change of temperature. They fly or break with ſome noiſe, when an attempt is made to cut them with the diamond, or to grind them on the wheel or other tool. The annealing is a remedy for this defect. It conſiſts in paſſing the glaſs, ſlowly and by inſenſible degrees, from the ſtate of ignition it poſſeſſes in the furnace of fuſion to the temperature of the atmoſphere. For this purpoſe, as ſoon as the work is finiſhed, and has aſſumed conſiſtence enough to retain its form, it is conveyed, while ſtill at a red heat, into a furnace which has nearly the ſame heat as itſelf. There the cooling is effected in one of the two following ways: The annealing furnace is filled with the manufactured articles, and kept at the ſame heat during the whole time of working, after which it is ſuffered to cool ſlowly together with its contents: or otherwiſe, one or ſeveral pieces newly made are gradually paſſed along the annealing furnace by occaſionally removing them from one end, which is hotteſt, to the other, where it is ſo low that the pieces may thence be ſafely transferred into the open air.

The ſlowneſs of annealing varies according to the brittleneſs of the kind of glaſs, and the thickneſs of the work. Thus a glaſs made with flint and alkali alone is more difficult to anneal than if it contained a metallic calx or lime; and the firſt kind will always be more ſubject to break by alternations of heat and cold. The veſſels to be annealed muſt be cool enough not to adhere to the ſupport on which they are placed; for the inequality of contraction between them and the ſupport might occaſion them to break. The ſame accident arrives to pieces made of glaſſes of different diſpoſitions to contract. The contraction of the piece to be annealed is effected more eaſily, the leſs friction it has to overcome: for which reaſon, when large plates of glaſs are to be annealed, the ſurface is placed on moveable bodies, ſuch as grains of ſand.

Concerning the principal Defects obſervable in Works made of Glaſs.

The moſt conſiderable defects, as enumerated by Mr. Loyſel, are ſtriæ or veins, threads, tears, cords, bubbles, and knots.

The ſtriæ or veins ariſe from the heterogeneous compoſition of the glaſs. It ſeldom happens that glaſſes of any conſiderable magnitude are exempt from them, and the reaſon is not difficult to explain.

Glaſs produced by the ſolution of ſiliceous earth by fixed alkali, at the ordinary heat of the glaſs-houſe, poſſeſſes a ſpecific gravity of twenty-three or twenty four, water being aſſumed as uſual at ten. Glaſs made with alkali and the clay commonly uſed weighs about twenty-five. That of alkali and chalk, twenty-ſeven or twenty-eight. The calx of mangane ſe vitrified alone weighs thirty-two or thirty-three. Glaſſes produced by other metallic calces are ſtill more ponderous: that of lead, for example, weighs about ſeventy-two or ſeventy-three. When the partial combinations of the ingredients of the glaſs are not well mixed together, but form ſtrata of different denſity in the pots, they produce undulated veins in the work ſimilar to thoſe obſerved when two liquids of very different denſities are firſt mixed, ſuch as water and ardent ſpirit.

As the glaſs in the operations of blowing is taken up nearly from the ſame part of the pot, and as in the caſting of glaſs the pot is ſuddenly reverſed and its whole contents mixed together, it is found that blown glaſs is much more uniform than that which has been caſt.

The name of threads is particularly given to thoſe veins which are produced by the vitrification of clay. They are greener than thoſe produced by calcareous earth. Theſe threads render the glaſs very brittle, when they are abundant, or when any of them are of conſiderable ſize, becauſe the contraction and dilatation of this kind of glaſs from change of temperature, are very different from thoſe of the glaſs of ſand and flint.

Tears are the greateſt defect which can be found in glaſs. They are the drops of glaſs afforded by the vitrification of the furnace of fuſion. Works in which theſe are found, are brittle. Moſt of them break by the alternations of temperature, and that the more ſurely, the nearer the tear is to the ſurface. Such articles are generally thrown aſide in the glaſs-houſe.

Cords are aſperities on the ſurface of certain articles of blown glaſs. They are produced whenever the heat of the furnace becomes ſo low, that the threads of glaſs which fall from the pipe into the crucible, cannot reſume the proper degree of fluidity. When this appearance preſents itſelf, the work is given up till the heat of the furnace is again brought to the requiſite degree.

The ſmall bubbles abundantly diffuſed through certain glaſſes ſhew that the refining is imperfect. They ariſe from the diſengagement of elaſtic fluid during the vitrification. This imperfection ſhews either that the quantity of flux has been too ſmall, or the fire too weak. In the firſt caſe, the glaſs may be uſed to hold liquids without fear of being attacked; in the ſecond, the glaſs is tender and eaſily acted on by acids, if the flux were of an alkaline nature, becauſe its proportion is too great.

Bubbles may alſo be produced in glaſs, during the working, by certain foreign matters which are fixed, and emit aerial fluid by the heat.

Knots are of three kinds. They are either formed by grains of ſand enveloped in the glaſs, or by the ſalt of glaſs which is found in pieces, or white flocks, or laſtly by pieces detached from the crucible or the ſides of the furnace.

SILK * is a fibre or thread ſpun by the ſilk-worm to form a nidus for its preſervation in the chryſalis ſtate. It is wound off in the manufactories, and afterwards joined or ſpun into thicker threads. We do not poſſeſs any explanation of the proceſs by which ſilk, which in the body of the inſect has the form of a glutinous unorganized maſs, becomes conſiſtent, firm, and very ſtrong, in an exceedingly ſhort time after it has been drawn out into thread. Anglers have a practice of cutting the body of a ſilk-worm, and drawing out the whole of the ſilky contents into a ſtring of a few inches long, which ſpeedily acquires conſiſtence, has the appearance of cat-gut or fiddle-ſtring, but is more tranſparent, and is on that account leſs viſible under water when uſed as a fiſhing-line. M. Chappe has made very intereſting reſearches as to the management of this matter. He diſſects the veſſels out of the ſilk-worm, waſhes them with water, and then dilutes their contents by trituration with about one third of its weight of water. By this preparation they could be blown into permanent globes, and otherwiſe formed. See Annales de Chimie, xi. 113.

Silk appears to be a ſort of dried gummy matter. It differs from vegetable ſub-

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* Chiefly from Berthollet.

ſtances, 1. in affording volatile alkali by diſtillation: 2. in affording azotic gas by treatment with nitrous acid: 3. in affording a peculiar oil, which is ſeparated from it when the nitrous acid converts it into acid of ſugar, as has been ſhewn by Berthollet. It ſeems to be a compound, conſiſting of a vegetable mucilage, with a peculiar animal oil which renders it pliant, ductile, and elaſtic.

Silk is naturally coated with a ſubſtance which has been conſidered as a gum, to which it owes its ſtiffneſs and elaſticity; that which is moſt commonly met with in France contains, beſides, a yellow colouring matter.

Moſt of the purpoſes for which ſilk is employed require that it ſhould be deprived not only of its colouring matter but alſo of its gum. Both theſe purpoſes are anſwered by means of ſoap, and the term ſcouring (décreuſage) is applied to this operation, by which it acquires its ſuppleneſs and whiteneſs. The ſcouring ought not to be ſo complete for ſilks which are to be dyed, as for thoſe which are intended to remain white; and a difference ought even to be made, according to the colour we mean the ſilk ſhould have.

This difference conſiſts chiefly in the quantity of ſoap employed: thus, for common colours, it is generally thought ſufficient to boil the ſilk for three or four hours in a ſolution of twenty pounds of ſoap for each hundred of ſilk, taking care to fill up the kettle with water from time to time, that there may be always a ſufficient proportion of fluid. The quantity of ſoap is increaſed for thoſe ſilks which are to be dyed blue, and more eſpecially for thoſe that are to be ſcarlet, cherry-colour, &c. becauſe for theſe colours the ground muſt be whiter than for ſuch as are leſs delicate. In treating of each colour, the quantity of ſoap proper for the ſilk intended to receive it is mentioned.

When ſilk is to be employed white, it undergoes three operations. The firſt is called by the French dégommage, and by our workmen ſhaking over; it conſiſts in keeping the hanks of ſilk in a ſolution of thirty pounds of ſoap to a hundred of ſilk: this ſolution ought to be very hot, but not boiling: when that part of the hanks which is immerſed is entirely freed from its gum, which is known by the whiteneſs it acquires, the hanks are turned upon the ſkein ſticks, ſo that the part which was not before immerſed may undergo the ſame operation; they are then taken out of the kettle and wrung out, according as the operation is completed.

The ſecond operation is the cuite or boiling. The ſilk is put into bags of coarſe cloth, five-and-twenty or thirty pounds in each bag, which is called a boiling bag (poche): a bath of ſoap is prepared like the former, but with a leſs quantity of ſoap; in this the bags are boiled for an hour and a half, taking care to keep them conſtantly ſtirred, that thoſe which touch the bottom of the kettle may not receive too much heat.

The third operation is called bleaching or whitening, which is principally intended to give the ſilk a ſlight caſt, to make the white more pleaſing; and from which it derives different names, ſuch as china white, ſilver white, azure white, or thread white. A ſolution of ſoap is prepared, the proper ſtrength for which is determined by its mode of frothing when agitated: for the china white, which ſhould have a ſlight tinge of red, a ſmall quantity of anotto is added, and the ſilk is ſhaken over in it until it has acquired the deſired ſhade. To the other whites, more or leſs of a blue tinge is given by adding a little blue to the ſolution of ſoap, though ſome had before been put into the cuite.

To prepare the azure, fine indigo is taken; and after being well waſhed two or three times in moderately warm water, it is ground fine in a mortar, and boiling water poured on it; it is then left to ſettle, and the liquor alone is employed, which retains only the moſt ſubtile parts: this is called azure. A ſmall quantity of the liquor of a freſh vat of indigo may be ſubſtituted for azure.

At Lyons, where they make a more beautiful white than at Paris, no ſoap is uſed in the third operation; but after the ſecond, the ſilks are waſhed, fumigated with ſulphur, and azured with river water. In this method it is of importance to employ very clear water.

When the ſilk has become very uniform, and has acquired the deſired ſhade, it is wrung out and dried.

The white obtained by theſe means is not yet ſufficiently bright for the ſilk intended for white ſtuffs; but muſt ſtill be expoſed to the vapour of ſulphur.

As ſoap ſeems to impair the luſtre of ſilk, the academy of Lyons, in 1761, propoſed as the ſubject of a prize-diſſertation to find a method of ſcouring ſilks without ſoap; and the prize was adjudged to Mr. Rigaut, of S. Quentin, who propoſed ſubſtituting for ſoap a ſolution of ſoda, or carbonat of ſoda, ſo much diluted with water as not to injure the ſilk; but ſome inconvenience muſt have attended the practice of this method, as it is not adopted, though generally known and eaſy of execution.

The Abbé Collomb * has publiſhed ſome obſervations highly worthy of attention, reſpecting the ſcouring of ſilk by the action of water alone. Having perceived that a ſkein of yellow ſilk, which he had boiled for about three hours in common water, had loſt nearly one eighth of its weight, he repeated the boiling twice, and thereby brought the diminution to nearly one quarter.

The ſilk which has ſuffered this loſs of weight ſtill retains a yellow or rather chamois colour, which renders it unfit for white ſtuffs, or for ſuch as are intended to receive any colour the beauty of which depends on the whiteneſs of the ground upon which it is applied: but it takes thoſe colours very well which cannot be injured by the tinge it retains; thus the black which it took ſeemed preferable to that of ſilk ſcoured with ſoap.

The ſilk remains very firm and ſtrong after this operation; the threads of it, compared with ſimilar ones ſcoured with ſoap, ſupported weights which broke the others.

Eight hours of briſk ebullition are required to diſſolve the whole gummy coat of ſilk, and it thereby loſes a little more than one fourth of its weight; but the boiling ought to be continued longer when the barometer is low, becauſe the greater the weight of the atmoſphere, the higher is the degree of heat at which water boils.

This conſideration led M. Collomb to try the effect of boiling ſilk in Papin's digeſter; and he found that only one hour and a quarter were required, to complete the ſolution of the gummy coat, although the degree of heat muſt have been inferior to that which produced many of thoſe effects obſerved by philoſophers, in that concentrated kind of ebullition.

Berthollet ſays that he ſaw a pattern of ſilk ſtuff ſcoured by M. Collomb; it ſeemed to have the qualities which he mentions; but it had leſs ſuppleneſs and ſoftneſs than ſilk ſcoured with ſoap.

M. Le Camus, a learned naturaliſt of the academy of Lyons, gave Berthollet a ſmall quantity of the ſubſtance ſeparated from ſilk by the water, in one of M. Collomb's

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* Obſervations ſur la Diſſolution du Vernis de la Soie. Journ. de Phyſ. Août, 1785.

Collomb's operations; it was black, brittle, and of a ſhining fracture, and afforded by diſtillation the uſual products of animal ſubſtances; it diſſolved eaſily in warm water, and left very little reſiduum on the filtre; the ſolution, which is tranſparent, and of a greeniſh yellow colour, was not ſenſibly affected by acids or alkalis.

Solution of alum produced in it a dirty white precipitate: that of copper, a dark brown precipitate; that of ſulphat of iron, a brown precipitate; ſolution of tin in aqua regia, a white precipitate; acetite of lead, a brown precipitate. All theſe precipitates are in ſmall quantity, and more or leſs viſcous. The infuſion of galls and that of ſumach produce a white precipitate.

Alcohol does not diſſolve this ſubſtance even by ebullition, taking up only a yellow colouring matter; this ſolution, by evaporation, afforded a reſiduum of ſcales of an amber yellow.

Berthollet added ſome drops of muriatic acid to nearly two ounces of alcohol, and boiled it on twenty grains of the ſilk gum: a ſolution took place; but, on cooling, this ſubſtance put on the appearance of jelly.

The ſubſtance taken from the ſilk in the ſcouring, then, appears to be of an animal nature, and therefore the ſoap-ſuds uſed in that operation ſoon become putrid; when ſeparated from the ſilk, it is eaſily diſſolved in water, but not in alcohol. Though not of a vegetable nature, it may with conſiderable propriety be called a gum. That part which gives it the yellow colour is ſoluble in alcohol, and when it is ſeparated the gum becomes brown. Is is not improbable that this colour is occaſioned by the heat to which it is expoſed in the boiling, becauſe when only the yellow colouring part is ſeparated by M. Baumé's proceſs, which will preſently be deſcribed, the ſilk is whitened.

In M. Collomb's proceſs the gum is ſeparated, and takes with it only ſome of the colouring particles; and in the proceſs of ſcouring by ſoap the gum and the yellow colouring particles are carried off together.

Berthollet boiled ſome yellow ſilk in a retort, where, as the vapours did not eſcape ſo freely as from an open veſſel, a degree of heat muſt have been produced ſuperior to that of water boiling in the open air. After having been boiled for four hours, the ſilk had loſt one fourth of its weight, but it had almoſt entirely retained its colour.

The ſame chemiſt boiled another pattern in the ſame way, in a quantity of water impregnated with common ſalt; it became whiter, but loſt leſs of its weight, though the degree of heat was certainly increaſed by the addition of the ſalt, which reſtrained the evaporation of the water: poſſibly a part of the ſalt had united with the ſilk. Experiments might be made with other ſalts; and perhaps we ſhould find ſome, that, without injuring the ſilk, might be more uſeful in diſſolving the gum and colouring particles.

When the ſilk is intended for the manufacture of blonds and gauzes, its natural elaſticity and ſtiffneſs ſhould be preſerved: the greateſt part of what is produced in France is of a yellow colour, but it is the white China ſilk that is principally uſed for theſe purpoſes; this is ſo dear, that the French manufacturers cannot vie with the Engliſh, from whom they get it, as the Engliſh always reſerve the fineſt for their own manufactures. It has therefore been a deſideratum to find out the means of depriving the yellow ſilk of its colouring particles, without deſtroying the gum, and thereby depriving the ſilk of its elaſticity. M. Baumé has ſolved this intereſting problem, but has kept his proceſs ſecret: ſome artiſts, however, to whom he had entruſted it, or who had been led to the diſcovery by their own obſervations, ſucceeded in the execution of it; but the proceſs appears to be liable to accidents, which by occaſioning loſs increaſe expence; ſo that hitherto, notwithſtanding the advantages it preſents, it has not been carried into execution. The following is an account of what has tranſpired reſpecting it:

A mixture is made with a ſmall quantity of marine acid and alcohol, in which the ſilk is immerſed; the marine acid muſt be pure, and not contain any nitrous acid, which makes the ſilk yellow. To give it an uniform white colour ſeems to be one of the moſt difficult parts of the proceſs, eſpecially when the operation takes place on large quantities. There is likewiſe great difficulty in dyeing the whitened ſilk, ſo as to prevent its curling; it ought certainly to be kept conſtantly ſtretched during the drying. The alcohol that has been impregnated with the colouring part muſt be again ſeparated from it, ſo as to ſerve for ſubſequent operations, otherwiſe the proceſs would be too expenſive; for this purpoſe it is to be diſtilled by a gentle heat, in a glaſs or ſtone-ware veſſel.

It appears from the experiments above related, that the marine acid is uſeful in this proceſs, by ſoftening the gum, and thus aſſiſting the alcohol to diſſolve the colouring particles combined with it.

The preparation with alum muſt be conſidered as one of the general operations in dyeing ſilk; for without aluming, the greateſt part of the colours applied would poſſeſs neither beauty nor durability.

The preparation with alum conſiſts in mixing in a tun or vat, about forty or fifty pails of water with forty or fifty pounds of Roman alum, that has been previouſly diſſolved in warm water; this muſt be carefully ſtirred during the mixture, to prevent the cryſtallization of the alum.

After having waſhed and bathed the ſilk, and wrung it out with the jack and pin*, in order to ſeparate any ſoap it may have retained, it is immerſed in the alum liquor, where it is left for eight or nine hours; after which it is wrung out by hand over the vat, and waſhed in a ſtream of water.

In the above quantity of liquor one hundred and fifty pounds of ſilk may be prepared, without the addition of any more alum; but when it begins to grow weak, which thoſe who are in the habit of employing it can eaſily diſtinguiſh by the taſte, twenty or twenty-five pounds of diſſolved alum muſt be added as before, and this addition muſt be repeated until the liquor acquires a diſagreeable ſmell; and then it may be employed in the preparation of ſtuffs intended for darker colours, ſuch as browns and marones, till it has loſt all its ſtrength.

The preparation of ſilk with alum is always made in the cold, becauſe when the liquor is employed hot the luſtre of the ſilk is liable to be impaired.

SILVER is the whiteſt of all metals, conſiderably harder than gold, very ductile and malleable, but leſs malleable than gold; for the continuity of its parts begins to break when it is hammered out into leaves of about the hundred and ſixty thouſandth of an inch thick, which is more than one third thicker than gold leaf: in this ſtate it does not tranſmit the light. Its ſpecific gravity is moderate, being inferior to platina, gold, mercury, and lead. It ignites before melting, and requires a ſtrong heat to fuſe it. The heat of common furnaces is inſufficient to calcine it: but the heat of the moſt powerful burning lenſes vitrifies a portion of it, and cauſes it to emit fumes; which, when received on a plate of gold, are found to be ſilver in the metallic ſtate. It has likewiſe been partly calcined by twenty ſucceſſive expoſures to the heat of the porcelain furnace at Sêves. The air alters it very little: though it is diſpoſed to obtain a thin purple or black coating from the ſulphureous vapours which are emitted from animal ſubſtances, drains, or putrefying matters. This coating, after a long ſeries of years, has been obſerved to ſcale off from images of ſilver expoſed in churches; and was found, on examination, to conſiſt of ſilver united with ſulphur.

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* This is a contrivance for wringing more ſtrongly than can be done by the hands alone; the pin introduced through the hank at one end, or into a twiſt of the cloth, is ſecured in a fixed poſition, while the other end or twiſt is fixed to the hook of the jack, which can be forcibly turned round by means of a winch connected with it. When this degree of force is not neceſſary, and the hands only are employed in the operation, it is called wringing out by hand.

Silver is ſoluble in the vitriolic acid when concentrated and boiling, and the metal in a ſtate of diviſion. The marine acid ſcarcely acts upon it, unleſs dephlogiſticated: but the nitrous acid diſſolves it with great rapidity, and with a plentiful diſengagement of nitrous air; which, during its extrication, gives a blue or green colour to the acid, that entirely diſappears if the ſilver made uſe of be pure; if it contain copper, the ſolution remains greeniſh; and if the acid contain either vitriolic or marine acid, theſe combine with a portion of the ſilver, and form ſcarcely ſoluble compounds, which fall to the bottom. If the ſilver contain gold, this metal ſeparates in blackiſh coloured flocks. The nitrous acid diſſolves more than half its weight of ſilver; and the ſolution is very cauſtic, that is to ſay, it deſtroys and corrodes animal ſubſtances very powerfully. This action appears to depend on the ſtrong diſpoſition of the ſilver to become revived; by which it either attracts phlogiſton from thoſe ſubſtances according to the ancient theory, or communicates vital air to them according to the new theory: ſo that the animal ſubſtances undergo a proceſs equivalent to combuſtion.

The ſolution of ſilver, when fully ſaturated, depoſits thin cryſtals as it cools, and alſo by evaporation. Theſe are called lunar nitre, or nitre of ſilver. A gentle heat is ſufficient to fuſe them, and drive off their water of cryſtallization. In this ſituation it is of a black colour, may be caſt into ſmall ſticks in a mould, and then forms the lapis infernalis, or lunar cauſtic, uſed in ſurgery. A ſtronger heat decompoſes lunar nitre, the acid flying off, and the ſilver remaining pure. It is obvious that, for the purpoſe of forming the lunar cauſtic, it is not neceſſary to ſuffer the ſalt to cryſtallize, but that it may be made by evaporating the ſolution of ſilver at once to dryneſs; and as ſoon as the ſalt is fuſed, and ceaſes to boil, it may be poured out. The nitrous acid driven off from lunar nitre is decompoſed, the products being vital air and phlogiſticated air.

Although the nitrous acid diſſolves ſilver with ſuch great facility, it appears to do this only in conſequence of its great power to calcine the metal: for the vitriolic and marine acids have a greater attraction for the calx. They accordingly take it from that acid, and form ſalts; which, as we have already obſerved, fall to the bottom on account of their difficult ſolubility. The vitriol of ſilver, which is formed by pouring vitriolic acid into the nitrous ſolution of ſilver, is ſparingly ſoluble in water; and on that account forms cryſtals, which are ſo ſmall that they compoſe a white powder. The marine acid precipitates from nitrous acid the ſaline compound called luna cornea, or horn ſilver; which has been ſo diſtinguiſhed becauſe, when melted and cooled, it forms a ſemi-tranſparent and partly flexible maſs, reſembling horn. It is ſuppoſed that a preparation of this kind has given riſe to the accounts of malleable glaſs.

If any ſalt with baſe of alkali, containing the marine acid, be added to the nitrous ſolution of ſilver, the ſame effect takes place by double affinity; the alkaline baſe uniting with the nitrous acid, and the ſilver falling down in combination with the marine acid.

Since the marine acid throws down only ſilver, lead, and mercury, and the latter of theſe two is not preſent in ſilver that has paſſed cupellation, though a ſmall quantity of copper may elude the ſcorification in that proceſs, the ſilver which may be revived from luna cornea is purer than can readily be obtained by any other means. When this ſalt is expoſed to a low red heat, its acid is not expelled; and a greater heat cauſes the whole concrete either to riſe in fumes, or to paſs through the pores of the veſſel. To reduce it, therefore, it is neceſſary that it ſhould be triturated with its own weight of fixed alkali, and a little water, and the whole afterwards expoſed to heat in a crucible whoſe bottom is covered with mineral alkali; the maſs of luna cornea being likewiſe covered with the ſame ſubſtance. In this way the acid will be ſeparated from the ſilver, which is reduced to its metallic ſtate.

As the precipitate of luna cornea is very perceptible, the nitrous ſolution of ſilver is uſed as a teſt of the preſence of marine acid in waters; for a drop of this ſolution poured into ſuch waters will cauſe a very evident cloudineſs. The ſolution of ſilver is alſo uſed by aſſayers to purify the nitrous acid from any admixture of marine acid. In this ſtate they call it precipitated aqua fortis.

The precipitates of ſilver which are formed by the addition of alkalis or earths are all reducible by mere heat, without the addition of any combuſtible ſubſtance. The fulminating combination of volatile alkali with ſilver, exhibits one of the moſt aſtoniſhing inſtances of chemical detonation hitherto known *. Pure ſilver is diſſolved in pale nitrous acid, and precipitated by the addition of lime water. This calx or precipitate, after decantation of the fluid, is to be dried by expoſure to the air for three days. The inventor thinks the preſence of light has ſome influence in the ſucceſs of the experiment. The dried calx being agitated or ſtirred in a ſolution of cauſtic volatile alkali, aſſumes the form of a black powder, from which the fluid is to be decanted, and the black ſubſtance left to dry in the air. This is the fulminating ſilver.

Gunpowder and fulminating gold are not to be compared with this new product; as the former requires ignition, and the latter a ſenſible degree of heat, to cauſe them to fulminate. But the ſlighteſt agitation or friction is ſufficient to cauſe the fulminating ſilver to explode. When it is once obtained, it can no more be touched. The falling of a few atoms of this preparation from a ſmall height produced the detonation; a drop of water falling on it had the ſame effect. No attempts therefore can be made to incloſe it in a bottle; but it muſt remain in the capſule wherein, by evaporation, it obtained this terrible property.

To make this experiment with ſafety, it is proper to uſe no greater quantity than a grain of ſilver; the laſt deſiccation ſhould be made in a metallic veſſel; and the face of the operator ſhould be defended by a maſk, with holes for the eyes defended with ſtrong glaſs.

The volatile alkali made uſe of in converting the calx of ſilver into the black precipitate, was expoſed to ebullition in a ſmall matraſs of glaſs; and the fluid being then ſuffered to cool, the inſide of the veſſel became lined with ſmall cryſtals. When one of theſe was touched beneath the cold liquor, an exploſion took place, which broke the matraſs in pieces, and threw the liquid up to the ceiling of the laboratory.

The inventor's theory of theſe effects is the ſame as that of fulminating gold. The combination conſiſts of volatile alkali and calx of ſilver; that is to ſay, in the

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* Diſcovered by Berthollet. See the Journal de Phyſique for June 1788, p. 474.

the new theory, of inflammable air, phlogiſticated air, ſilver, and vital air. The ſlighteſt change of temperature or agitation diſpoſes the inflammable air to combine with the vital air, which adheres very feebly to the ſilver. Theſe form water, while the phlogiſticated air is diſengaged, and the ſilver reduced to the metallic ſtate. The exploſion depends on the ſudden tranſition of the phlogiſticated air and the water to the elaſtic ſtate by heat: but the change of capacity from which the heat ariſes has not yet been explained. On the phlogiſtic theory, it will be ſaid, that the ſilver is revived by combining with the inflammable air, or phlogiſton of the alkali; while the phlogiſticated and vital air fly off in the exploſion.

Chemiſts have long been acquainted with the compound acid called aqua regia, from its action being exerted on few of the metals except gold. But the diſcovery of a compound acid acting ſtill more excluſively upon ſilver, is due to one of our contemporaries Mr. Keir. The effects of aqua regia have been deſcribed, conſidered and explained by a great variety of authors. Thoſe of Mr. Keir's compound acid are confined to the Philoſophical Tranſactions; a work which, though its circulation extends to every part of the globe, is comparatively ſpeaking confined to few hands. For this reaſon, it appears proper to give an ample account of the experiments of this chemiſt.

Mr. Keir's paper * conſiſts of two parts: the firſt ſhews the effects of compounding the vitriolic and nitrous acids in diſſolving metals, and the other deſcribing ſome curious appearances which occur in the precipitation of ſilver, from its ſolution in nitrous acid by iron, and by ſome other ſubſtances.

PART I. SECTION I.

Effects of compounding the vitriolic and nitrous Acids upon the Diſſolution of Metals †.

No two ſubſtances, ſays the author, are more frequently in the hands of chemiſts and artiſts than vitriolic acid and nitre; yet, he ſays, he has found that a mere mixture of theſe, when much concentrated, poſſeſſes properties which neither the vitriolic nor nitrous acid, of the ſame degree of concentration, have ſingly, and which could not eaſily be deduced à priori, by reaſoning from our preſent knowledge of the theory of chemiſtry.

Having found by ſome previous trials, that a mixture compoſed of nitre, diſſolved in oil of vitriol, was capable of diſſolving ſilver eaſily and copiouſly, while it did not affect copper, iron, lead, regulus of cobalt, gold and platina; he conceived that it might be uſeful in ſome caſes of the parting of ſilver from copper, and the other metals above mentioned; and having alſo obſerved, that the diſſolving powers of the mixture of vitriolic and nitrous acids varied greatly in different degrees of concentration and phlogiſtication, he thought an inveſtigation of theſe effects might be a ſubject fit for philoſophical chemiſtry, and might tend to illuſtrate the theory of the diſſolution of metals in acids: with theſe views he made the following experiments:

EXPERIMENT I.

Into a long necked retort, the contents of which, including the neck, were 1400 grain meaſures, 100 grain meaſures of oil of vitriol were put, of the uſual denſity at which it is prepared in England, i. e. whoſe ſpecific gravity is to that of water as 1.844 to 1, and 100 grains of pure and clear nitre, which was then diſſolved in the acid by the heat of a water bath. To this mixture 100 grains of ſtandard ſilver were added; the retort was ſet in a water bath, in which the water was made to boil, and a pneumatic apparatus was applied to catch any air or gas which might be extricated.

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* Philoſophical Tranſactions, 1790. Part 2.

† To prevent any confuſion of terms, Mr. Keir confines the word *ſolution* to expreſs the ſubſtance diſſolved, together with its ſolvent, and the word *diſſolution* to denote the act of diſſolving.

The ſilver began to diſſolve, and the ſolution became of a purple or violet colour. No air was thrown into the inverted jar, excepting a little of the common air of the retort, by means of the expanſion which it ſuffered from the heat of the water-bath, and from ſome nitrous fumes which appeared in the retort, and which having afterwards condenſed, occaſioned the water to riſe along the neck of the retort, and mix with the ſolution. The remaining ſilver was then ſeparated and weighed, and it was found that 39 grains had been diſſolved; but probably more would have been diſſolved, if the operation had not been interrupted by the water ruſhing into the retort.

Experiment II.

In the ſame apparatus, 200 grains of ſtandard ſilver were added to a mixture of 100 grains of nitre, previouſly diſſolved in 200 grain meaſures of oil of vitriol; and in this ſolvent 92 grains of the ſilver were diſſolved, without any production of air or gas. The ſolution, which was of a violet colour, having been poured out of the retort while warm (for with ſo large a proportion of nitre, ſuch mixtures, eſpecially after having diſſolved ſilver, are apt to congeal with ſmall degrees of cold), in order to ſeparate the undiſſolved ſilver from it, and having been returned into the retort without this ſilver; 200 grains of water were poured into the retort, upon which a ſtrong efferveſcence took place between the ſolution and the water, and 3100 grain meaſures of nitrous gas were thrown into the inverted jar. Upon pouring 200 grains more of water into the retort, 600 grain meaſures of the ſame gas were expelled. Further additions of water yielded no more gas; neither did the ſilver, when afterwards added to this diluted ſolution, give any ſenſible efferveſcence, or ſuffer a greater loſs of weight than 2 grains.

Experiment III.

In the ſame apparatus, 100 grains of ſtandard ſilver were expoſed to a mixture of 30 grains of nitre diſſolved in 200 grain meaſures of oil of vitriol: and in this operation 80 grains of ſilver were diſſolved, while at the ſame time 4500 grain meaſures of nitrous gas were thrown into the inverted jar. When the undiſſolved ſilver was removed, 200 grains of water were added to the ſolution, which was of a violet-colour, and upon the mixture of the two fluids an efferveſcence happened; but only a few bubbles of nitrous gas were then expelled.

Experiment IV.

In the ſame apparatus 100 grains of ſtandard ſilver were expoſed to a mixture of 200 grain meaſures of oil of vitriol, 200 grains of nitre, and 200 grains of water; and in this operation 20 grains of the ſilver were diſſolved without any ſenſible emiſſion of air or gas.

Mr. Keir remarks that in theſe experiments the copper contained in the ſtandard ſilver gave a reddiſh colour to the ſaline maſs which was formed in the ſolution, and ſeemed to be a calx of copper interſperſed through the ſalt of ſilver. This was all the difference he could perceive between the effects of pure and ſtandard ſilver diſſolved in this acid.

Tin was next expoſed to the ſame mixture of oil of vitriol and nitre, in the ſame apparatus, and in the ſame circumſtances, care being always taken to add more metal than could be diſſolved, that by weighing the remainder, the quantity capable of being diſſolved might be found, as had been done with the experiments on ſilver: the reſults were as follow:

EXPERIMENT V.

No tin was diſſolved nor calcined by the mixture in the proportion of 200 grain meaſures of oil of vitriol to 200 grains of nitre, nor by another mixture in the proportion of 200 grain meaſures of oil of vitriol to 150 grains of nitre, and conſequently no gas was produced in either inſtance.

EXPERIMENT VI.

With a mixture in the proportion of 200 grain meaſures of oil of vitriol and 100 grains of nitre, the tin began ſoon to be acted upon, and to be diffuſed through the liquor; but no extrication of gas appeared until the digeſtion had been continued two hours in boiling water; and then it took place, and gave a frothy appearance to the mixture, which was of an opaque white colour, from the powder of tin diffuſed among it. In this experiment the quantity of tin thus calcined was 73 grains, and the quantity of nitrous gas extricated during this action on the tin, was 8500 grain meaſures. Then, upon pouring 200 grains of water into the retort, a freſh effervefcence took place between the water and the white opaque maſs, and 4600 grain meaſures of nitrous gas were thrown into the inverted receiver.

EXPERIMENT VII.

With a mixture in the proportion of 100 grain meaſures of oil of vitriol to 30 grains of nitre, 30 grains of tin were diſſolved or calcined, and the nitrous gas, which began to be extricated much ſooner than in the laſt-mentioned experiment, with a larger proportion of nitre, amounted to 6300 grain meaſures. Water added to this ſolution of tin did not produce any effervefcence.

EXPERIMENT VIII.

With a mixture in the proportion of 200 grain meaſures of oil of vitriol, 200 grains of nitre, and 200 grains of water, 133 grains of tin were acted on with an effervefcence, which took place violently, and produced 6500 grain meaſures of nitrous gas.

The ſeveral mixtures above mentioned, in different proportions of nitre and oil of vitriol, did by the help of the heat of a water-bath calcine mercury into a white or grayiſh powder. Nickel was alſo partly calcined and partly diſſolved by thoſe mixtures. It was not perceived that any other metal was affected by them, excepting that the ſurfaces of ſome of them were tarniſhed.

Theſe mixtures of oil of vitriol and nitre, the author obſerves, were apt to congeal by cold, thoſe eſpecially which had a large proportion of nitre. Thus, a mixture of 1000 grain meaſures of oil of vitriol, and 480 grains of nitre, after having kept fluid ſeveral days in a phial not ſo accurately ſtopped as to prevent altogether the eſcape of ſome white fumes, congealed at the temperature of 55° of Fahrenheit's thermometer; whereas ſome of the ſame liquid having been mixed with equal parts of oil of vitriol, did not congeal with a leſs cold than 45°. The congelation is promoted by expoſure to air, by which white fumes riſe, and moiſture may be abſorbed, or by any other mode of ſlight dilution with water.

Dilution of this compound acid with more or leſs water, alters conſiderably its properties, with regard to its action on metals. Thus, in its concentrated ſtate it does not act on iron; but by adding water, it acquires a power of acting on that metal, and with different effect, according to the proportion of the water added. Thus, by adding to two meaſures of the compound acid, one meaſure of water, the liquor is rendered capable of calcining iron, and forming with it a white powder, but without effervefcence. With an equal meaſure of water effervefcence was produced. With a larger proportion of water the iron gave alſo a brown colour to the liquor, ſuch as phlogiſticated nitrous acid acquires from iron, or communicates to a ſolution of martial vitriol in water.

Dilution with water renders this compound acid capable of diſſolving copper, zinc, and probably thoſe other metals which are ſubject to the action of the dilute vitriolic or nitrous acids.

SECTION II.

New Proceſs for ſeparating Silver from Copper.

The properties of this liquor in diſſolving ſilver eaſily without acting on copper, have rendered it capable of a very uſeful application in the arts. Among the manufactures at Birmingham, that of making veſſels of ſilver plated on copper is a very conſiderable one. On cutting out the rolled plated metal into pieces of the required form and ſizes, there are many ſhreds, or ſcraps as they are called, unfit for any purpoſe but the recovery of the metals by ſeparating them from each other. The eaſieſt and moſt œconomical method of parting theſe two metals, ſo as not to loſe either of them, is an object of ſome conſequence to the manufacturers. For this purpoſe, two modes were practiſed: one, by melting the whole of the mixed metals with lead, and ſeparating them by eliquation and teſting; and the ſecond, by diſſolving both metals in oil of vitriol, with the help of heat, and by ſeparating the vitriol of copper, by diſſolving it in water, from the vitriol of ſilver, which is afterwards to be reduced and purified. In the firſt of theſe methods, there is a conſiderable waſte of lead and copper; and in the ſecond, the quantity of vitriolic acid employed is very great, as much more is diſſipated in the form of volatile vitriolic or ſulphureous acid than remains in the compoſition of the two vitriols.

Some years ago, the author communicated to an artiſt the method of effecting the ſeparation of ſilver and copper, by means of the above-mentioned compound of vitriolic acid and nitre; and as it is now commonly practiſed by the manufacturers in Birmingham, he thinks it is much more œconomical, it is certainly much more eaſily executed, than any of the other methods: for nothing more is required than to put the pieces of plated metal into an earthen glazed pan; to pour upon them ſome of the acid liquor, which may be in the proportion of eight or ten pounds of oil of vitriol to one pound of nitre; to ſtir them about, that the ſurfaces may be frequently expoſed to freſh liquor, and to aſſiſt the action by a gentle heat from 100° to 200° of Fahrenheit's ſcale. When the liquor is nearly ſaturated, the ſilver is to be precipitated from it by common ſalt, which forms a luna cornea, eaſily reducible by melting it in a crucible with a ſufficient quantity of pot-aſh; and, laſtly, by refining the melted ſilver if neceſſary, with a little nitre thrown upon it. In this manner the ſilver will be obtained ſufficiently pure, and the copper will remain unchanged. Otherwiſe, the ſilver may be precipitated in its metallic ſtate, by adding to the ſolution of ſilver a few of the pieces of copper, and a ſufficient quantity of water to enable the liquor to act upon the copper.

The property which this acid mixture poſſeſſes of diſſolving ſilver with great facility, and in conſiderable quantity, will probably render it an uſeful menſtruum in the ſeparation of ſilver from other metals; and as the alchemiſts have diſtinguiſhed the peculiar ſolvent of gold under the title of aqua regis, a name ſufficiently diſtinctive, though founded on a fanciful alluſion; ſo, if they had been acquainted with the properties of this compound, they would probably have beſtowed on it the appellation of aqua reginæ.

SECTION III.

Change of Properties communicated to the Mixture of vitriolic and nitrous Acids by Phlogiſtication.

The above-deſcribed compound acid may be phlogiſticated in different methods, of which the author mentions three.

Firſt. By digeſting the compound acid with ſulphur, by means of the heat of a water-bath: the liquor diſſolves the ſulphur with effervеſcence, loſes its property of yielding white fumes; and if the quantity of ſulphur be ſufficient, and the heat applied be long enough continued, it exhibits red nitrous vapours, and aſſumes a violet colour.

Secondly. If inſtead of diſſolving nitre in concentrated vitriolic acid, this acid be impregnated with nitrous gas, or with nitrous vapour; by making this gas or vapour paſs into the acid, this compound will be phlogiſticated, as it contains not the entire nitrous acid, but only its phlogiſticated part or element, the nitrous gas, without the proportion of pure air neceſſary to conſtitute an acid. This impregnation of oil of vitriol with nitrous gas, or nitrous vapour, was firſt deſcribed, and ſome of the properties of the impregnated liquor noticed, by Dr. Prieſtley*.

Thirdly. By ſubſtituting nitrous ammoniac inſtead of nitre in the mixture with oil of vitriol.

The compound prepared by any of theſe methods, but eſpecially by the firſt and ſecond, differs conſiderably in its properties with regard to its action on metals, from the acid deſcribed in the firſt ſection. It has been obſerved that the latter compound has little action on any metals, but ſilver, tin, mercury, and nickel. On the other hand, the phlogiſticated compound not only acts on theſe, but alſo on ſeveral others. It forms with iron a beautiful roſe-coloured ſolution, without application of any artificial heat; and in time a roſe-coloured ſaline precipitate is depoſited, which is ſoluble in water, with a conſiderable effervеſcence. It diſſolves copper, and acquires from this metal, and alſo from regulus of cobalt, zinc, and lead, pretty deep violet tinges. Biſmuth, and regulus of antimony, were alſo attacked by this phlogiſticated acid.

To aſcertain more exactly the effects of this phlogiſticated acid on ſome metals, the author made the following experiments, with a liquor prepared by making nitrous gas paſs through oil of vitriol during a conſiderable time.

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* See Experiments and Obſervations on Air, vol. iii. p. 129 and 217.

EXPE-

EXPERIMENT I.

To 200 grain meaſures of the oil of vitriol, impregnated with nitrous gas, put into a retort with a long neck, the capacity of which, including the neck, was 1150 grain meaſures, 144 grains of ſtandard ſilver were added, and the mouth of the retort was immerſed in water, under an inverted jar filled with water, to catch the gas which might be extricated.

The acid began to diſſolve the ſilver with effervefcence, without application of heat; the ſolution became of a violet colour, and the quantity of nitrous gas received in the inverted jar was 14700 grain meaſures. Upon weighing the ſilver remaining, the quantity which had been diſſolved was found to be 70 grains. When water was added to the ſolution, an effervefcence appeared, but only a very ſmall quantity of gas was extricated. By means of the water, a white ſaline powder of ſilver, ſoluble in a larger quantity of water, was precipitated from the ſolution. The ſolution of ſilver, when ſaturated and undiluted, congeals readily in cool temperatures, and, when diluted to a certain degree with water, gives foliated cryſtals.

EXPERIMENT II.

In the ſame apparatus, and in the ſame manner, 100 grain meaſures of this impregnated oil of vitriol were applied to iron. An effervefcence appeared without application of heat, the ſurface of the iron acquired a beautiful roſe-colour, or redneſs mixed with purple: and this colour gradually pervaded the whole liquor, but diſappeared on keeping the retort ſome time in hot water. Notwithſtanding a conſiderable apparent effervefcence, the quantity of air expelled into the inverted jar was only 400 grain meaſures, of which one quarter was nitrous, and the reſt phlogiſticated. The ſolution was then poured out of the retort, and the iron was found to have loſt only two grains in weight. The ſolution was returned into the retort without the iron, and 200 grains of water were added to it; upon which a white powder was immediately precipitated, which re-diſſolved with great effervefcence. When 2000 grain meaſures of nitrous gas had been expelled into the inverted jar, without application of heat, the retort was placed in the water-bath, the heat of which rendered the effervefcence ſo ſtrong, that the liquor boiled over the neck of the retort, ſo that the quantity of gas extricated could not be aſcertained.

EXPERIMENT III.

In the ſame manner, 11 grains of copper were diſſolved in 100 grain meaſures of impregnated oil of vitriol. The ſolution was of a deep violet colour, and at laſt was turbid. The quantity of nitrous gas expelled into the inverted jar, during the operation, was 4700 grain meaſures. When the copper was removed, and 200 grains of water were added to the ſolution, an effervefcence took place, 1700 grain meaſures of nitrous gas were expelled, and the ſolution then acquired a blue colour.

EXPERIMENT IV.

With the ſame quantity of impregnated oil of vitriol, tin was reduced in weight 16 grains: the liquor acquired a violet colour, became turbid by the ſuſpenſion of the calx of tin, and 4100 grain meaſures of nitrous gas were extricated without heat, and 4900 with heat.

EXPERIMENT V.

Mercury treated in the ſame manner formed a thick turbid liquor, which was rendered clear by adding unimpregnated oil of vitriol. The liquor ſoon afterwards acquired a purple colour, the mercury ſunk to the bottom, in the form of a white powder; and the purple liquor, when a ſolution of common ſalt in water was added to it, ſhewed no ſigns of containing mercury in a diſſolved ſtate.

The nitrous gas with which the oil of vitriol is impregnated ſhews no diſpoſition to quit the acid by expoſure to air; but on adding water, the gas is expelled ſuddenly with great effervesſcence, and with red fumes. Thus,

EXPERIMENT VI.

Upon adding 240 grains of water to 60 grain meaſures of impregnated oil of vitriol, 2,300 grains of nitrous gas were thrown into the receiver; but as the action of the two liquors is inſtantaneous, the quantity of gas expelled from the retort before its neck could be immerſed in water and placed under the receiver, muſt have been conſiderable. The whole of the gas, however, was not extricated by means of the water; for the remaining liquor diſſolved five grains of copper, while 800 meaſures of nitrous gas were thrown into the retort.

From the preceding experiments Mr. Keir deduces the following facts:

1. That a mixture of the vitriolic and nitrous acids in a concentrated ſtate, has a peculiar faculty of diſſolving ſilver copiouſly.

2. That it acts upon, and principally calcines tin, mercury, and nickel (the latter of which, however, it diſſolves in ſmall quantity), and that it has little or no action on other metals.

3. That the quantity of gas produced while the metal is diſſolving is greater, relatively to the quantity of metal diſſolved, when the proportion of nitre to the vitriolic acid is ſmall, than when it is large; and that when the metals are diſſolved by mixtures containing much nitre, and with a ſmall production of gas, the ſolution itſelf, or the metallic ſalt formed in it, yields abundance of gas when mixed with water.

4. That dilution with water renders the concentrated mixture leſs capable of diſſolving ſilver, but more capable of acting on other metals.

5. That this mixture of highly concentrated vitriolic and nitrous acids acquires a purple or violet colour when phlogiſticated, either by addition of inflammable ſubſtances, or ſulphur, or by its action on metals, or by very ſtrong impregnation of oil of vitriol with nitrous gas *.

6. That this phlogiſtication was found to communicate to the mixture the power of diſſolving, though in ſmall quantities, copper, iron, zinc, and regulus of cobalt.

7. That water expels from a highly phlogiſticated mixture of concentrated vitriolic and nitrous acids, or of oil of vitriol impregnated with nitrous gas, a great part of its contained gas, and that therefore this gas is not capable of being retained in ſuch quantity by dilute as by concentrated acids. Water unites with the mixture of oil of vitriol and nitre, without any conſiderable effervesſcence.

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* Mr. Keir obſerves, that Dr. Prieſtley has noticed this colour communicated to oil of vitriol by impregnation with nitrous gas or vapour, and alſo the effervesſcence produced by adding water. See Experiments and Obſervations, vol. iii. p. 129 and 217.

To theſe obſervations the author ſubjoins another fact, viz. that when to the mixture of oil of vitriol with nitre a ſaturated ſolution of common ſalt in water is added, a powerful aqua regis is produced, capable of diſſolving gold and platina; and this aqua regis, though compoſed of liquors perfectly colourleſs, and free from all metallic matter, acquires at once a bright and deep yellow colour. The addition of dry common ſalt to the concentrated mixtures of vitriolic and nitrous acids produces an effervefcence, but not the yellow colour; for the production of which, therefore, a certain proportion of water ſeems to be neceſſary.

PART II.

On the Precipitation of Silver from Nitrous Acid by Iron.

Mr. Keir introduces his account of the experiments which are the ſubject of this part of his paper, by remarking, that Bergman * relates, that upon adding iron to a ſolution of ſilver in nitrous acid no precipitation enſued, although the affinity of iron to acids in general is known to be much ſtronger than that of ſilver; and although even with regard to the nitrous acid, other experiments evince the ſuperior affinity of iron: for as iron precipitates copper from this acid, and as copper precipitates ſilver, we muſt infer, he obſerves, the greater affinity of iron than that of ſilver. In the courſe of Bergman's experiments, however, ſome inſtances of precipitation occurred, which he attributed to the peculiar quality of the irons thus employed. With a view to diſcover the circumſtances, and to inveſtigate the cauſe of this irregularity and exception to the general received laws of affinity, Mr. Keir made the following experiments:

EXPERIMENT I.

A piece of fine ſilver was digeſted in pure and pale nitrous acid; and while the diſſolution was going on, and before the ſaturation was completed, a portion of the ſolution was poured upon pieces of clean and newly-ſcraped iron wire into a wine glaſs, and a ſudden and copious precipitation of ſilver enſued. The precipitate was at firſt black, then it aſſumed the appearance of ſilver, and was five or ſix times larger in diameter than the piece of iron wire which it enveloped. The action of the acid on the iron continued ſome little time, and then it ceaſed; the ſilver re-diſſolved, the liquor became clear, and the iron remained bright and undiſturbed in the ſolution at the bottom of the wine glaſs, where it continued during ſeveral weeks, without ſuffering any change, or effecting any precipitation of the ſilver.

EXPERIMENT II.

When the ſolution of ſilver was completely ſaturated, it was no longer affected by iron, according to Bergman's obſervation.

EXPERIMENT III.

Mr. Keir having found that the ſolution acted on the iron, and was thereby precipitated before it had been ſaturated, and not afterwards, was deſirous of knowing whether the ſaturation was the circumſtance which prevented the action and precipitation. For this purpoſe he added to a portion of the ſaturated ſolution ſome of the ſame nitrous acid, of which a part had been employed to diſſolve the ſilver; and into this mixture, abounding with a ſuperfluous acid, he threw a piece of iron, but no precipitation occurred. It was thence evident, that the ſaturation of the acid was not the only circumſtance which prevented the precipitation.

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* Diſſertatio de Phlogiſt. Quantitate in Metallis.

Experiment IV.

To another portion of the ſaturated ſolution of ſilver, ſome red ſmoking nitrous acid was added; and upon trial, it was found, that iron precipitated the ſilver from this mixture, and that the ſame appearances were exhibited which had been obſerved with the ſolution previouſly to its ſaturation.

Experiment V.

The ſame effects were produced when vitriolic acid was added to the ſaturated ſolution of ſilver, and iron afterwards applied.

Experiment VI.

To ſome of the ſame nitrous acid, of which a part had been employed to diſſolve the ſilver, a piece of iron was added; and while the iron was diſſolving, ſome of the ſaturated ſolution of ſilver was poured into the liquor; upon which a precipitation of ſilver took place inſtantly; although when the ſame acid had been previouſly mixed with the ſolution of ſilver, and the iron was then added to the mixture, no precipitation had enſued.

Experiment VII.

The quantity of vitriolic acid, or of the red fuming nitrous acid, neceſſary to communicate to the ſaturated ſolution of ſilver the property of being acted on by iron, varies according to the concentration, and to the degree of phlogiſtication of the acid added; ſo that a leſs quantity than is ſufficient does not produce any apparent effect. Nevertheleſs, when the ſolution of ſilver is by addition of theſe acids brought nearly to a precipitable ſtate, the addition of ſpirit of wine will, in a little time, render it capable of acting on iron.

It appears then, that a ſolution of ſilver is not precipitated by iron in cold, unleſs it have a ſuperabundance of phlogiſticated acid.

Experiment VIII.

Heat affects the action of a ſolution of ſilver on iron; for if iron be digeſted with heat in a perfectly ſaturated ſolution of ſilver, ſuch as a ſolution of cryſtals of nitre of ſilver in water, the ſilver will be depoſited in its bright metallic ſtate on different parts of the iron, and the iron which has been acted on by the ſolution, appears in form of a yellow ochre.

Experiment IX.

Bergman relates, that he has ſometimes obſerved beautiful cryſtallizations or vegetations of metallic ſilver formed on pieces of iron immerſed long in a ſolution of ſilver. Mr. Keir obſerves, he has found that no time is able to effect this depoſition, unleſs the ſolution be in a ſtate *nearly* ſufficiently phlogiſticated to admit of a precipitation by iron, but not completely phlogiſticated enough to effect that purpoſe immediately.

Experiment X.

Dilution with a great deal of water ſeemed to diſpoſe the ſolutions of ſilver to be precipitated by iron more eaſily. A ſolution of ſilver, which did not act on iron, upon being very much diluted, and having a piece of iron immerſed in it, during ſeveral hours, gave a precipitate of ſilver in the form of a black powder.

Section II.

On the Alterations which Iron on its Surface undergoes by the Action of a Solution of Silver in Nitrous Acid, or of a pure concentrated Nitrous Acid.

It has been ſaid, that when iron is expoſed to the action of a phlogiſticated ſolution of ſilver, it inſtantly precipitates the ſilver, is itſelf acted upon or diſſolved by the acid ſolution, during a certain time, longer or ſhorter, according to the degree of phlogiſtication, quantity of ſuperabundant acid, and other circumſtances; and that at length the ſolution of the iron ceaſes; the ſilver precipitate is re-diſſolved, if there is ſuperfluous acid; the liquor becomes clear again, but only rendered a little browner by its having diſſolved ſome iron; while the piece of iron remains bright and undiſturbed at the bottom of the liquor, where it is no longer able to affect the ſolution of ſilver.

Experiment I.

A part of the phlogiſticated ſolution of ſilver which had paſſed through theſe changes, and which had ceaſed to act upon the piece of iron, was poured into another glaſs, and another piece of freſh iron wire was dropped into the liquor, upon which a precipitation of the ſilver enſued, a ſolution of part of the iron, a re diſſolution of the precipitated ſilver, and a ceſſation of all thoſe phenomena, with the iron remaining bright and quiet at the bottom of the liquor, as before. It appeared then, that the liquor had not loſt its power of acting on freſh iron, although it ceaſed to act on that piece which had been expoſed to it.

Experiment II.

To one of the pieces of iron which had been employed in the precipitation of a ſolution of ſilver, and from which the ſolution no longer capable of acting upon it had been poured off, ſome phlogiſticated ſolution of ſilver was added, which had never been expoſed to the action of iron, but no precipitation happened.

It appeared then, that the iron itſelf, by having been once employed to precipitate a ſolution of ſilver, was rendered incapable of any further action on any ſolution of ſilver. And it is to be obſerved, that this alteration was produced without the leaſt diminution of its metallic ſplendour, or change of colour. The alteration, however, was only ſuperficial, as may be ſuppoſed; for, by ſcraping off its altered coat, it was again rendered capable of acting on a ſolution of ſilver. Mr. Keir calls iron thus affected *altered* iron; and iron which is clean, and has not been altered, freſh iron.

Experiment III.

To a phlogiſticated ſolution of ſilver, in which a piece of bright altered iron lay, without action, a piece of freſh iron was added, which was inſtantly enveloped with a maſs of precipitated ſilver, and acted on as uſual; but what is very remarkable, in about a quarter of a minute or leſs the altered iron ſuddenly was covered with another coat of precipitated ſilver, and was now acted on by the acid ſolution like the freſh piece. In a little time the ſilver precipitate was re-diſſolved, as uſual, and the two pieces of iron were reduced to an altered ſtate. When a freſh piece of iron was then held in the liquor, ſo as not to touch the two pieces of altered iron, they were nevertheleſs ſoon acted upon by the acid ſolution, and ſuddenly covered with ſilver precipitate as before; and theſe phenomena may be repeated with the ſame ſolution of ſilver, till the ſuperfluous acid of the ſolution becomes ſaturated by the iron, and then the re-diſſolution of the precipitated ſilver muſt ceaſe.

EXPERIMENT IV.

Some dephlogiſticated nitrous acid was poured on a piece of altered iron, without any action enſuing, although this acid readily acted on freſh iron; and when to the dephlogiſticated nitrous acid, with a piece of altered iron lying immerſed in it, a piece of freſh iron was added, this immediately began to diſſolve, and ſoon afterwards the altered iron was acted on alſo by the acid.

EXPERIMENT V.

Upon a piece of altered iron a ſolution of copper in nitrous acid was poured; but the copper was not precipitated by the iron; neither did this iron precipitate copper from a ſolution of blue vitriol.

EXPERIMENT VI.

Altered iron was acted on by a dilute phlogiſticated nitrous acid; but not by a red concentrated acid, which is known to be highly phlogiſticated.

EXPERIMENT VII.

Some pieces of clean freſh iron wire were put into a concentrated and red fuming nitrous acid. No apparent action enſued; but the iron was found to be altered, in the ſame manner as it is by a ſolution of ſilver, i. e. it was rendered incapable of being attacked either by a phlogiſticated ſolution of ſilver, or by dephlogiſticated nitrous acid.

EXPERIMENT VIII.

Iron was alſo altered by being immerſed ſome little time in a ſaturated ſolution of ſilver, which did not ſhew any viſible action on it.

The alteration thus produced on the iron is very ſuperficial. The leaſt rubbing expoſes ſome of the freſh iron beneath the ſurface, and thus ſubjects it to the action of the acid.

It is therefore with difficulty that theſe pieces of altered iron can be dried, without loſing their peculiar property. For this reaſon Mr. Keir generally transferred them out of the ſolution of ſilver, or concentrated nitrous acid, into any other liquor, the effects of which he wanted to examine. Or they may be transferred firſt into a glaſs of water, and thence into the liquor to be examined. But it is to be obſerved, that if they are allowed to remain long in the water, they loſe their peculiar property or alteration. They may be preſerved in their altered ſtate, by being kept in ſpirit of ſal ammoniac.

EXPERIMENT IX.

To a ſaturated ſolution of copper in nitrous acid (which was capable of being readily precipitated by freſh iron) ſome ſaturated ſolution of ſilver was added. From this mixture, a piece of freſh iron neither precipitated ſilver nor copper: nor did the addition of ſome dephlogiſticated nitrous acid effect this precipitation.

Experiment X.

A ſolution of copper, formed by precipitating ſilver from nitrous acid, by means of copper, was very reluctantly and ſlowly precipitated by a piece of freſh iron; and the iron thus acted on by the acid was changed to an ochre.

Experiment XI.

A ſaturated ſolution of ſilver having been partly precipitated by copper, acquired the property of acting upon freſh iron, and of being thereby precipitated.

Experiment XII.

Freſh iron immerſed ſome time in ſolutions of nitre of lead, or of nitre of mercury in water, did not occaſion any precipitation of the diſſolved metals; but acquired an altered quality. Theſe metals taken in this reſpect reſemble ſilver.

Experiment XIII.

It is well known that a ſolution of martial vitriol, added to a ſolution of gold in aqua regis, precipitates the gold in its metallic ſtate. Mr. Keir remarks, he does not recollect that the precipitation of a ſolution of ſilver, by the ſame martial vitriol, has been obſerved. However, upon pouring a ſolution of martial vitriol into a ſolution of ſilver, in the nitrous acid, a precipitate will be thrown down, which acquires in a few minutes more and more of a metallic appearance, and is indeed perfect ſilver. When the two ſolutions are pretty well concentrated, a bright argentine film ſwims on the ſurface of the mixture, or ſilvers the ſides of the glaſs in which the experiment is made. When a phlogiſticated ſolution of ſilver is uſed, the mixture is blackened, as happens generally to a ſolution of martial vitriol, when a phlogiſticated nitrous acid is added to it.

Experiment XIV.

Equal parts of water were added to a mixture of phlogiſticated ſolution of ſilver, and a ſolution of martial vitriol, in which all the ſilver had been precipitated, and the dilute mixture was digeſted with heat; by which means moſt of the precipitated ſilver was re-diſſolved. Bergman has obſerved a ſimilar re-diſſolution of gold, precipitated by martial vitriol, upon boiling the mixture; but he attributes the re-diſſolution to the concentration of the aqua regis by the evaporation. As this explanation did not accord with Mr. Keir's notions, he diluted the mixture with water, and found that the ſame re-diſſolution occurred both with the ſolution of ſilver and with that of gold. But he did not find that the re-diſſolution ever took place with either of the metals, unleſs there had been a ſuperabundant acid in the ſolutions of gold and ſilver employed.

Experiment XV.

Mercury is alſo precipitated in its metallic ſtate, from its ſolution in nitrous acid, by a ſolution of martial vitriol. When the liquor is poured off from the precipitate, this may be changed into running mercury, by being dried near the fire.

Experiment XVI.

Mr. Keir found alſo, that ſilver may be precipitated in its metallic ſtate, from its ſolution in vitriolic acid, by addition of a ſolution of martial vitriol.

A vitriol of mercury may alſo be decompounded by a ſolution of martial vitriol; and the mercurial precipitate, which is a black powder, forms globules, when dried and warmed.

Experiment XVII.

Luna cornea is not decompounded by martial vitriol; conſequently there is an operation of a double affinity. Nevertheleſs, this luna cornea may be decompounded by the elements of martial vitriol, while they are in the act of diſſolution; that is, the ſilver may be precipitated in its metallic ſtate, by digeſting luna cornea with a dilute vitriolic acid, to which ſome pieces of iron are added. And it is to be obſerved, that the reduction of the ſilver and precipitation take place while the acid is yet unſaturated. Marine acid and iron applied to luna cornea effect the ſame reduction of the ſilver to a metallic ſtate, even when there is more acid than is ſufficient for both metals *.

Sulphur combines readily with ſilver in the dry way; but may be ſeparated by a ſtronger heat. The ſulphur of liver of ſulphur likewiſe blackens ſilver, and combines with it, whether the ſilver be immerſed in the liquid ſolution, or expoſed to hepatic air.

Aqua regia acts ſtrongly on ſilver; but precipitates it in the form of luna cornea as faſt as it is diſſolved. This effect may be eaſily underſtood by conſidering that the nitrous acid diſſolves the ſilver, and the marine precipitates it.

The neutral ſalts alone do not alter ſilver either in the moiſt or dry way; nitre, in particular, does not deflagrate with this metal.

Moſt metallic ſubſtances precipitate ſilver in the metallic ſtate from its ſolution. The aſſayers make uſe of copper to ſeparate the ſilver from the nitrous acid uſed in the proceſs of parting. The precipitation of ſilver by mercury is very ſlow, and produces a peculiar ſymmetrical arrangement, called the tree of Diana. In this, as in all precipitations, the peculiar form may be affected by a variety of concomitant circumſtances; for which reaſon one proceſs uſually ſucceeds better than another. Lemery directs that an ounce of fine ſilver be diſſolved in a ſufficient quantity of very pure and moderately ſtrong nitrous acid; that this ſolution be mixed in a matraſs, or bottle, with about twenty ounces of diſtilled water; and that, after the addition of two ounces of mercury, the whole be ſuffered to repoſe. During the ſpace of forty days a kind of tree of ſilver will be formed on the ſurface of the mercury, with branches greatly reſembling a vegetable ſubſtance in its ramifications. The foregoing proceſs is ſaid by Macquer to ſucceed very well; but the following of Homberg is much ſhorter:

Make an amalgam, without heat, of four drams of leaf ſilver with two drams of mercury. Diſſolve this amalgam in four ounces, on a ſufficient quantity of pure nitrous acid of a moderate ſtrength; dilute this ſolution in about a pound and a half of diſtilled water; agitate the mixture, and preſerve it for uſe in a glaſs bottle with a ground ſtopper. When this preparation is to be uſed, the quantity of one ounce is put into a phial, and the ſize of a pea of amalgam of gold or ſilver, as ſoft as butter, is to be added; after which the veſſel muſt be left at reſt. Soon afterwards ſmall filaments appear to iſſue out of the ball of amalgam, which quickly increaſe, and ſhoot out branches in the form of ſhrubs.

In the above experiment of Lemery, the nitrous acid depoſits its ſilver at the

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* Keir ends the account of Mr. Keir's experiments.

ſame time that it takes up mercury; and, in conſequence of the liquor being ſo much diluted, the proceſs goes on ſlowly, and the precipitated ſilver has time to arrange itſelf according to the law of its cryſtallization, whether that depend on the polarity of its particles, or on any other property not yet explained. In the method of Homberg, there are two circumſtances which appear calculated to forward the proceſs: in the firſt place, the nitrous acid already contains mercury in ſolution, which may probably render it more diſpoſed to part with the ſilver; and, in the next place, the mercury is combined with ſilver or gold in the form of an amalgam. Theſe may perhaps facilitate the precipitation of the ſilver, by preſenting a baſe for it to combine with; which may be more perfectly at repoſe, becauſe leſs agitable than the fluid mercury in the former experiment. After all, however, though the general theory of the experiment is not difficult, yet it does not ſeem eaſy to point out the effectual cauſe of the differences between the two reſults.

Silver unites with gold by fuſion, and forms a pale alloy, as has been already mentioned in treating of that metal. With platina it forms a hard mixture, rather yellower than ſilver itſelf, and of difficult fuſion. The two metals do not unite well. Silver melted with one tenth part of crude platina, from which the ferruginous particles had been ſeparated by a ſtrong magnet, could not be rendered clear of ſcabrous parts, though it was repeatedly fuſed, poured out, and laminated between rollers. It was then fuſed, and ſuffered to cool in the crucible, but with no better ſucceſs. After it had been formed, by rolling and hammering, into a ſpoon for blow-pipe experiments, it was expoſed to a low red heat, and became rough, and bliſtered over its whole ſurface. The quantities were one hundred grains of ſilver and ten grains of platina. Nitre was added during the fuſions.

Silver very readily combines with mercury. A very ſenſible degree of heat is produced when ſilver leaf and mercury are kneaded together in the palm of the hand. With lead it forms a ſoft maſs, leſs ſonorous than pure ſilver. With copper it becomes harder and more ſonorous, at the ſame time that it remains ſufficiently ductile: this mixture is uſed in the Britiſh coinage. Fifteen parts of ſilver, alloyed with one of copper, form the compound called ſtandard ſilver. The mixture of ſilver and iron has been little examined. With tin it forms a compound, which, like that of gold with the ſame metal, has been ſaid to be brittle, however ſmall the proportion; though there is probably as little foundation for the aſſertion in the one caſe as in the other. With biſmuth, arſenic, zinc, and antimony, it forms brittle compounds. It does not unite with nickel. The compound of ſilver and wolfram, in the proportion of two of the former to one of the latter, was extended under the hammer during a few ſtrokes; but afterwards ſplit in pieces.

Silver is found either native or mineralized. The native ſilver is found in Peru and various parts of Europe; ſometimes in conſiderable maſſes, and often diffuſed through ſand, ochre, or lime-ſtone. It is ſeldom pure, but is generally alloyed with copper, and ſometimes with gold, iron, or regulus of antimony. The mineralized ſilver contains ſulphur and arſenic, or both, with other admixtures.

Native ſilver may be purified by pounding or waſhing, or amalgamation with mercury; and the ſilver itſelf is refined by cupellation with lead in the ſame manner as gold. In the large way, the litharge, or vitrified lead, is blown from the ſurface of the ſilver by bellows, inſtead of ſoaking into the crucible. Gold may be ſeparated from ſilver by parting with aqua regia, or treatment with ſulphur in the dry way, which combines with the ſilver, and leaves the gold diſengaged.

The vitreous ſilver ore is the richeſt ore of ſilver, and contains from ſeventy to eighty pounds of ſilver in the hundred weight; the reſt being ſulphur, with rarely any other metal, except a ſmall portion of iron. It is found either in ſolid large lumps, or inherent in quartz or ſpar. Its colour generally reſembles that of lead; but grows dark by expoſure to the air. It uſually poſſeſſes a ſlight degree of malleability, and is ſufficiently ſoft to be cut by a knife.

To analyſe this ore in the moiſt way, it may be boiled in nitrous acid, which acidifies the ſulphur, and cauſes great part to fly off in the form of vitriolic acid air. Common ſalt, or marine acid, will precipitate the ſilver in the form of luna cornea, which may be either reduced, or accounted for by deducting one fourth of its weight when waſhed and dried, which fourth of its weight is marine acid.

In the dry way, it may be reduced by expoſing it to a heat not ſufficient to melt it. In this way the ſulphur is diſſipated, and the ſilver remains uſually in a fibrous form. Small portions may be conveniently decompoſed in this manner by the blow-pipe upon charcoal.

The red ſilver ore is a heavy ſhining ſubſtance, either tranſparent or opake; ſometimes gray or blackiſh, but always reddiſh when powdered: it uſually contains more than half, and ſometimes three-fourths of its weight of ſilver, the reſt being arſenic and ſulphur.

In the moiſt way this ore is analyſed by reducing it to fine powder, and boiling it with diluted nitrous acid. The reſidue, which contains the ſulphur and the arſenic, muſt be edulcorated with water; and the arſenic may be diſſolved by boiling in a ſufficient quantity of aqua regia. If the ſulphur ſhould retain any luna cornea, it may be ſeparated by keeping it for ſome days in a cloſed veſſel, with its own weight of diluted cauſtic volatile alkali. The clear nitrous ſolution being mixed with the water uſed in the edulcoration, affords a precipitate of luna cornea by the addition of ſea ſalt, which may either be reduced, or accounted for in the ſame manner as in the aſſay of the vitreous ſilver ore.

Silver united with ſulphur, arſenic, and copper, is generally called the white ore of ſilver. One hundred grains of this being reduced to a powder, and gently boiled for an hour in more than twelve times its weight of diluted nitrous acid, the copper and ſilver are diſſolved, and a white reſiduum remains. The ſilver is precipitated in the metallic form by the immerſion of a clean plate of copper; and the copper being afterwards precipitated by the addition of volatile alkali, may be accounted for by allowing 194 grains of the precipitate to 100 of the copper, and deducting the loſs ſuſtained by the plate of copper which was immerſed in the ſolution. The white reſiduum may be deprived of its arſenic and iron by boiling in marine acid. The arſenic may be precipitated by the addition of water; and afterwards the iron, if any, by Pruſſian alkali. The undiſſolved ſulphur may be treated with volatile alkali, to try whether it contains either copper or luna cornea.

The other ores of ſilver, of which there is conſiderable variety, may be analyſed by varying the proceſſes according to the ſuppoſed or known general contents of the ore *.

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* For which conſult Bergman's Treatiſe on the Art of Aſſaying in the Humid Way, inſerted in the ſecond volume of the Engliſh tranſlation of his Opuſcula, or Eſſays.

Sulphureous and arſenical ſilver ores may be aſſayed by roaſting, and ſubſequent fuſion with a greater or leſs quantity of flux. In the fuſion, the ſilver is obtained alloyed with lead, copper, or iron, which may be ſeparated by cupellation with lead, and the ſilver left pure. The fineneſs of ſilver is denoted by the aſſayers by mentioning the number of pennyweights and grains of pure ſilver contained in the ounce. So that if an ounce of ſilver be found to loſe half a pennyweight by cupellation, it is ſaid to be eleven pennyweights twelve grains fine; if it loſe a whole pennyweight, it is ſaid to be eleven pennyweights fine, &c. Silver is likewiſe tried by the touch, in the ſame manner as gold. For this purpoſe the aſſayers are provided with a ſet of needles, or ſmall bars; the firſt of which contains $\frac{1}{16}$ part of its weight of copper, and the reſt ſilver; the ſecond contains $\frac{2}{16}$ parts of copper; the third $\frac{3}{16}$ parts; and ſo on to the laſt, which contains 15 parts of copper to one of ſilver. By the reſemblance of colour on the touchſtone, an eſtimate may be made of the fineneſs of the ſilver to ſomething nearer than the 30th part of the whole, which is a conſiderable acquiſition in the examination of ſmall articles, ſuch as rings, trinkets and the like. It is true indeed that the uſe of the touch ſuppoſes the precious metal to be alloyed with copper only, which may not be the caſe; and conſequently the aſſayer is liable to be deceived in this reſpect: but he may in this caſe have recourſe to aqua fortis, or the blow-pipe, in the ſame manner as directed in the article gold.

In the large works, where ſilver is extracted, the proceſſes are grounded on the properties already deſcribed. Native ſilver is triturated with mercury; after which the amalgam is waſhed, to ſeparate the earthy particles; and the quickſilver ſeparated, partly by preſſure in leathern bags, and partly by diſtillation in iron retorts.

Rich ſulphureous ores are roaſted, and fuſed with lead, to refine the ſilver by cupellation. The poorer ores, which contain copper, are fuſed with pyrites, which affords a maſs conſiſting of copper, ſulphur, and ſilver. Lead is then added, and the maſs treated in the way of eliquation. The lead flows out, carrying the ſilver with it; and laſtly, theſe two metals are ſeparated by the teſt, on which the lead is converted into litharge, and the ſilver remains pure.

The uſes of ſilver are well known: it is chiefly applied to the forming of various utenſils for domeſtic uſe, and as the medium of exchange in money. Its diſpoſition to aſſume a black colour by tarniſhing, and its ſoftneſs, appear to be the chief objection to its uſe in the conſtruction of graduated inſtruments for aſtronomical and other purpoſes, in which a good white metal would be a deſirable acquiſition.

SILVERING. There are various methods of giving a covering of ſilver or ſilvery aſpect to the ſurfaces of bodies. The application of ſilver leaf is made in the ſame way as that of gold, for which ſee GILDING. Copper may be ſilvered over by rubbing it with the following powder: Two drams of tartar, the ſame quantity of common ſalt, and half a dram of alum, are mixed with fifteen or twenty grains of ſilver precipitated from nitrous acid by copper. The ſurface of the copper becomes white when rubbed with this powder, which may afterwards be bruſhed off and poliſhed with leather. The ſadlers and harneſs makers cover their wares with tin for ordinary uſes, but a cheap ſilvering is uſed for this purpoſe as follows: Half an ounce of ſilver that has been precipitated from aqua fortis by the addition of copper, common ſalt and ſal ammoniac, of each two ounces, and one dram of corroſive ſublimate, are triturated together, and made into a paſte with water; with this, copper utenſils of every kind, that have been previouſly boiled with tartar and alum, are rubbed, after which they are made red hot, and then poliſhed. The intention of this proceſs appears to be little more than to apply the ſilver in a ſtate of minute diviſion to the clean ſurface of the copper, and afterwards to fix it there by fuſion; and accordingly this ſilvering may be effected by uſing the argentine precipitate here mentioned, with borax or mercury, and cauſing it to adhere by fuſion. The dial plates of clocks, the ſcales of barometers, and other ſimilar articles are ſilvered by rubbing upon them a mixture of luna cornea, ſea-ſalt, and tartar, and afterwards carefully waſhing off the ſaline matter with water. In this operation, the ſilver is precipitated from the marine acid, which unites with part of the coppery ſurface. It is not durable, but may be improved by heating the article, and repeating the operation till the covering ſeems ſufficiently thick. The ſilvering of pins is effected by boiling them with tin filings and tartar. The explanation of this effect is difficult. It ſhould ſeem as if the order of the affinities was changed by the increaſe of temperature; ſo that the tin may be taken up at a lower temperature by the acid, and give place to the braſs at a greater heat. But ſee TINNING.

In the ſilvering of looking-glaſſes, like the preceding operation, no ſilver is uſed. A leaf of tin foil, which muſt be thicker the larger its dimenſions, is evenly ſpread upon a ſmooth ſtone table furniſhed with a rim. Upon this mercury is poured in a ſmall quantity at firſt, and ſoftly bruſhed about till the whole ſurface of the tin appears bright by amalgamation. At this period, the mercury has corroded the upper ſurface only of the tin; but if the operation were to reſt here, its texture would ſoon be entirely deſtroyed by a total combination. The workman then pours a conſiderable quantity of mercury upon the table. A ſheet or piece of paper with a neat cut edge is then applied over one of the rims of the table, and upon it the plate of glaſs intended to be ſilvered. The plate is then ſlided onward, and comes in contact with the mercurial ſurface, ſo as not only to prevent the interpoſition of bubbles of air, which would enſue from a perpendicular application, but likewiſe in a great meaſure to drive the duſt and other impurities before it. As ſoon as the whole ſurface of the glaſs is thus applied to the mercury, the paper is withdrawn, and weights placed on the glaſs, ſo as to bring it into cloſe contact with the amalgamated tin foil. The ſuperfluous mercury is then decanted off, and the glaſs ſuffered to remain undiſturbed for a day or more. During this time, the mercury applied between the ſurface of the glaſs and the tin, becomes gradually abſorbed by the latter, and forms a hard amalgam, which is not eaſily injured or removed, and is further defended by the frame into which looking-glaſſes are uſually ſet.

The convex ſurfaces of glaſs mirrors are ſilvered in the ſame manner, but inſtead of a flat table, a mould of plaſter of Paris is made uſe of. Hollow mirrors or globes are ſilvered by an amalgam conſiſting of one part by weight of biſmuth, half a part of lead, the ſame quantity of pure tin, and two parts mercury. The imperfect metals are to be firſt fuſed together, and the mercury then added when the mixture is almoſt cold. A very gentle heat is ſufficient to fuſe this amalgam. In this ſtate it is poured into a clean glaſs globe intended to be ſilvered, by means of a paper funnel which reaches to the bottom. At a certain temperature, it will ſtick to the glaſs, which by a proper motion may thus be ſilvered completely, and the ſuperfluous amalgam poured out. The appearance of theſe toys is varied by uſing glaſs of different colours, ſuch as yellow, blue or green.

SINOPLE is a dark red jaſper or flint, which ſtrikes fire with ſteel, and affords in the dry way 10 per cent. of iron, and melts into a black ſlag. Rinm. Hiſt. Ferri, § 189. If tried with the Pruſſian alkali, it would probably ſhew eighteen or twenty parts of iron, as this always ſeparates nearly double the quantity of iron that can be extracted in the dry way.

SINTER. See STALACTITES.

SLATE. This name is given to argillaceous opake ſtones, which poſſeſs the well known property of breaking or ſplitting into plates or laminæ. The ſixth, ſeventh, and eighth ſpecies of Kirwan's argillaceous gems comprehend the ſlates or ſhiſti.

Of the roof ſlate, or ſhiſtus tegularis, he reckons four varieties, none of which has been hitherto analyſed, except the blueiſh-purple ſlate, chiefly uſed in London, which he examined, and to which, as to a ſtandard, he refers the other ſorts.

VARIETY I. Clay intimately mixed with 1.77 of its weight of ſiliceous earth, 0.3 of its weight of magneſia, 0.15 of calcareous earth, both ſlightly aerated, and nearly 0.54 of its weight of iron, beſides a ſlight admixture of mineral oil. This forms blueiſh-purple ſlate. It does not ſtrike fire with ſteel, and may be lightly ſcraped with the nail: it is very brittle, and of a lamellar texture: its ſpecific gravity is 2.876: when in pieces of $\frac{1}{4}$ of an inch thick, or leſs, it gives a clear ſound if ſtruck: its grain is moderately fine: it is never tranſparent: it ſlightly efferveſces with acids when reduced to powder, otherwiſe not: when heated red, it loſes ſomething more than 2 per cent. of its weight, ſlightly detonates with nitre, and then aſſumes a browniſh red colour, but calcination does not render it magnetic: in a ſtronger heat it is fuſible without addition, and forms a black ſcoria: it is difficultly diſſolved by mineral alkali in the dry way, more eaſily by borax, though with little efferveſcence, and alſo by microcoſmic ſalt with ſome efferveſcence. Mr. Gerhard remarks, that it melts with equal eaſe in chalk or clay veſſels.

Colourleſs acid of nitre, after ſtanding on it two months in cold, aſſumes a green colour.

Kirwan found 100 grains of it to contain about 46 of ſilex, 26 of argill, 8 of magneſia, 4 of calcareous earth, and 14 of iron. Part of the iron ſeems to be in a phlogiſticated ſtate, from its union with the oil, and part in a dephlogiſticated ſtate, or that of a red calx. This is united to the argillaceous part and ſilex, and is very difficultly ſeparated.

VARIETY II. Pale, ſlightly purple, or blueiſh ſhiſtus. This ſtone is harder than the foregoing, its laminæ thicker, and its texture coarſer: it ſeems to contain a larger proportion of the ſiliceous, and a ſmaller of the martial ingredient.

VARIETY III. Blue ſhiſtus. The proportion of the earthy ingredients being the ſame as in the firſt variety, that of the martial ingredients ſeems to be ſmaller.

Other ſtones are alſo uſed for covering houſes in various countries, but they are eaſily diſtinguiſhed; as their laminæ are much thicker, their ſurface more uneven, and their texture coarſer. They chiefly belong to the claſs of ſand ſtones, or to the calcareous genus.

VARIETY IV. Dark blue ſlate, ſhiſtus ſcriptorius. It efferveſces more briſkly with acids, and ſeems to contain more magneſia, and leſs iron, than the firſt variety: its ſpecific gravity is 2.701.

The pyritaceous ſpecies conſiſts of earth mixed with a variable proportion of pyrites, with a little magneſia and calcareous earth.

Its colour is gray, brown, blue, or black: it is more or leſs decompoſable by expoſure to the air, according to the quantity of the pyritous ingredient and the ſtate of the iron in the pyrites: if the iron be in a ſemi-phlogiſticated ſtate, it is eaſily decompoſed; but if the calx of iron be already much dephlogiſticated, it will be decompoſed but ſlowly, if at all. Aluminous ſhiſtus is of this ſpecies.

The bituminous ſhiſtus is intimately mixed with a notable proportion of mineral oil or bitumen.

It is generally black, of a lamellar texture, of different degrees of hardneſs, but never gives fire with ſteel: it emits a ſtrong ſmell when heated, and ſometimes without heat; and does not ſhew white when ſcraped.

To theſe may be added, 1. The argillaceous ſhiſtus or flag-ſtone. It conſiſts of clay mixed with from three to four tenths of its weight of ſilex, and a little of the yellow or red calx of iron. It is of a grey, yellowiſh, or reddiſh white colour; does not give fire with ſteel, nor effervesce with acids: its ſpecific gravity is from 2.6 to 2.78: it is in ſome places uſed for covering of houſes, but moſtly for flooring; it is ſometimes compact, and ſometimes ſandy, and then its ſpecific gravity is ſmaller.

2. The argillaceous grit, free-ſtone, or ſand ſtone. This may be cut eaſily in all directions: its texture is more or leſs porous, equable, and rough to the touch: it exhales an earthy ſmell when freſh broken and breathed upon: it does not give fire with ſteel, nor effervesce with acids. That from Hollington, near Utoxeter, is of a whitiſh or yellowiſh gray, and its ſpecific gravity 2.288. That from Kniperſly, in Staffordſhire, is of a blueiſh gray, and ſo infuſible as to be uſed for a fire-ſtone: its ſpecific gravity is 2.568.

SMALT. See Zaffre.

SMARAGDUS. See Precious Stones, No. VII.

SMECTIS. See Steatites.

SMELL, PRINCIPLE OF. Subſtances diſſolved or ſuſpended in the atmoſphere are found to act with peculiar energy on the organs of ſmell. Such permanently elaſtic fluids as are deſtructive of animal life, as for example, alkaline air emitted from the concrete alkali commonly called ſmelling ſalts, vitriolic acid air formed when ſulphur is burning, nitrous air from aqua fortis, and the like, produce effects to which ſcarcely any individual is a ſtranger. Every chemical operation is attended with the extrication of more or leſs volatile matter. Even the metals and glaſs affect the organ of ſmell, probably by ſome evolation; and the ſmells emitted by organized ſubſtances in every ſtage of their exiſtence, are among the moſt remarkable of their ſecondary properties.

The principle of ſmell in plants appears to be of an exceedingly ſubtile nature. It ſeems in general to reſide in the eſſential oil, and compoſes an extremely ſmall part of the weight of vegetables, as may be inferred from the loſs of fragrance ſuſtained by eſſential oils, with little or no loſs of their weight. This however does not neceſſarily ſuppoſe that the whole principle of ſmell has flown off; becauſe it may with equal probability be ſuppoſed to have entered into combination with ſome of the other principles of the ſubſtance which afforded it. Diſtillation with ſpirit of wine is uſed to extract the fragrant principle from plants. A conſiderable proportion of this matter may be obtained by diſtillation with water, in which it comes over probably diffuſed with a ſmall proportion of eſſential oil. It has been ſuppoſed to conſiſt of an elaſtic fluid of a peculiar nature.

SMELTING OF ORES. The ſeparation of metallic ſubſtances from their ores in the large way by heat, is called ſmelting. For the proceſſes, See Ores.

SNOW OF ANTIMONY. This name has been given to the white calx obtained by ſublimation from regulus of antimony.

SOAP is a ſaline compound, formed from fat or inflammable bodies, which not being ſoluble in water by themſelves, compoſe, by the aſſiſtance of ſalts, a homogeneous maſs ſoluble in water. Theſe ſubſtances are ſlippery to the touch, ſoluble in water and ſpirit of wine, and commonly lather and froth with theſe fluids, upon being agitated with them; they alſo render ſeveral other ſubſtances miſcible with water. They are diſcriminated from each other, not only by the various ſalts, but likewiſe by the different ſorts of fat ſubſtances employed in their preparation. Similar combinations alſo are found ready formed in nature, though theſe are leſs in uſe, and require to be adapted by art to the different purpoſes to which they may be applied.

Different vegetables very evidently exhibit by nature a ſaponaceous quality in their compoſition, of which ſoap wort, the ſoap-berry tree (Sapindus ſaponaria), and the common night-ſhade, may be adduced as inſtances. Now ſince the period that we have been convinced of the preſence of alkaline ſalts in vegetables, nothing is eaſier than to conceive the origin of a mixture of this kind. In proportion therefore as this ſalt and the oily parts exceed the reſt in quantity, and the force of the alkali is not weakened at the ſame time by the preſence of a mineral acid, ſuch vegetable will be more or leſs of a ſaponaceous nature. Sometimes alſo, though more rarely, a ſaponaceous compound is met with in vegetables which conſiſt of oleaginous particles and an acid. For this reaſon it is neceſſary in every caſe, previous to attempting to aſcertain the compoſition of one of theſe compounds, to ſee of what kind it is. With this view, the watery extract of the ſaponaceous plant needs only to be mixed with a ſolution of fixed alkaline ſalt, and notice taken whether any precipitation or ſeparation of the conſtituent parts enſues or not. If in this operation the mixture is not obſerved to become turbid, but that an acid on being added to it produces this effect, it may reaſonably be inferred, that this ſaponaceous compound has an alkaline ſalt for its baſis. But if upon the addition of an acid to ſuch extract no alteration enſues, and it is, on the contrary, rendered turbid by an alkali, it may be concluded that the compoſition is ſaponaceous with an acid baſis.

A perfect ſoap cannot be produced by art with acids. From the commixture of fluid acids and oily ſubſtances, no other than greaſy, ſaponaceous maſſes are produced, which, though they are miſcible with water, cannot be brought into a ſolid and concrete ſtate, and at the ſame time preſerve their ſaponaceous qualities.

The alkaline ſalts, on the contrary, are intermediate ſubſtances, by which all oleaginous or other inflammable bodies may be brought into a perfectly ſaponaceous ſtate But in order to promote the combination propoſed, they muſt neceſſarily be deprived of fixed air, by boiling with quick-lime.

With the fixed alkaline ſalts, the mineral as well as vegetable alkali, tallow-ſoaps are prepared in the following manner: One part of either of theſe alkaline ſalts, and about two parts of quick-lime, or as much as is requiſite to render them perfectly cauſtic, are to be mixed together, and made into a ſtrong ley, with the neceſſary quantity of water. This ley is then made to boil with three parts of tallow or fat over a gentle fire, and kept continually ſtirring, till the mixture becomes thick, and ceaſes to adhere to the hand, when a little is taken out of it for a ſample. Towards the end, a proportional quantity of common ſalt is added, by which the ſoap acquires a greater degree of hardneſs.

This effect has been accounted for on various ſuppoſitions. It has been ſaid, that the quantity of water preſent is diminiſhed by the abſtraction of as much as the ſalt requires for its ſolution; a circumſtance probably of little conſequence. Again, the ſoap is rendered leſs ſoluble in the water by this addition; and therefore more readily ſeparates. But the moſt important effect ſeems to be, that the marine acid of the ſalt attracts the vegetable alkali of the ſoap, and gives its own mineral alkali in return, which is known to afford a much harder ſoap. The weight of the ſoap here acquired is commonly, as Wiegleb ſays, double that of the tallow employed in making it. In the ſame manner a wax ſoap may be prepared either of yellow or white wax, which is about three times the weight of the wax, is very hard and firm, and has an agreeable ſmell of almonds. The Gravenhorſts in Brunſwick likewiſe prepare a ſoap of cocoa butter for medical uſes. Sperma cæti alſo may be made into ſoap with a cauſtic ley.

Macquer gives us the following proceſs for oil ſoap: One part of quicklime and two parts of good Spaniſh ſoda are boiled together during a ſhort time, with twelve times as much water, in an iron cauldron. This lixivium is to be filtered, and evaporated by heat, till a phial which is capable of containing an ounce of water ſhall contain an ounce and three gros of this concentrated lixivium. One part of this lixivium is to be mixed with two parts of oil of olives, or of ſweet almonds, in a glaſs or ſtone-ware veſſel. The mixture is to be ſtirred from time to time with an iron ſpatula, or with a peſtle, and it ſoon becomes thick and white. The combination is gradually completed, and in ſeven or eight days a very white and firm ſoap is obtained.

For the coarſer ſorts of ſoap cheaper oils are employed, ſuch as oil of nuts, linſeed, hemp, fiſh, &c. Either of theſe kinds of ſoap, to be good, muſt not feel greaſy or unctuous in water, nor exhibit any veſtige of fat upon the water. It ought farther to diſſolve eaſily in water, and lather well, as likewiſe be eaſily ſoluble in ſpirit of wine. It muſt not become moiſt in the air, nor throw out a ſaline efflореſcence on its external ſurface. When a ſolution of ſoap in ſpirit of wine is poured into river or ſpring water, a precipitation enſues, and a great part of the precipitate is no longer ſoluble in water. All ſoaps are decompoſed again by acids, and the fat matter ſeparated from them. The alteration however, which the fat and oils undergo on this occaſion, is very remarkable. They are now ſoluble in ſpirit of wine, whereas before the caſe was quite otherwiſe; the cauſe of which depends on the action of the matter of fire upon theſe bodies; and indeed the naked fire manifeſtly exerts the ſame effect upon them in ſuch caſes, in which it converts them into empyreumatic oils. In the ſouthern countries, mineral alkali, but in the northern countries the common vegetable alkali, is more commonly employed in the manufacture of ſoap. With mere lime-water a ſaponaceous greaſy mixture only, but no ſolid ſoap, can be obtained. Beſides the above-mentioned fat ſubſtances, a reſinous ſoap may alſo be made from the coarſer kinds of reſin with cauſtic ley. The compound reſulting from this union partakes at the ſame time of the properties of oil and of alkali; but theſe properties are modified and tempered by each other, according to the general rule of combinations. Alkali formed into ſoap has not nearly the ſame acrimony as when it is pure; it is even deprived of almoſt all its cauſticity, and its other ſaline alkaline properties are almoſt entirely aboliſhed. The ſame oil contained in ſoap is leſs combuſtible than when pure, from its union with the alkali, which is an uninflammable body. It is miſcible, or even ſoluble in water to a certain degree, by means of the alkali. Soap is entirely ſoluble

luble in ſpirit of wine, and ſtill better in aqua vitæ ſharpened by a little alkaline ſalt, according to an obſervation of Mr. Geoffroy.

When oil unites with alkali in the formation of ſoap, it is little altered in the connexion of its principles; for it may be ſeparated from the alkali by decompoſing ſoap with any acid, and may be obtained nearly in its original ſtate. By the accurate inveſtigation that Mr. Geoffroy has made of ſoap, by decompoſing it thus by means of an acid, he found that two ounces of this compound conſiſt of one ounce three gros and one ſcruple of oil, one gros and a ſcruple of marine alkali deprived of all moiſture, or twice the quantity of this ſalt containing the water of its cryſtallization; and laſtly, two gros and four grains of water. This latter quantity of water is nevertheleſs variable, according to the condition of the ſoap; for it may be much more or much leſs dry.

Concerning the decompoſition of ſoap by means of acids we muſt obſerve, firſt, that all acids, even the weakeſt vegetable acids, may occaſion this decompoſition, becauſe every one of them has a greater affinity than oil with fixed alkali. Secondly, theſe acids, even when united with any baſis, excepting a fixed alkali, or the inflammable principle, are capable of occaſioning the ſame decompoſition; whence all ammoniacal ſalts, all ſalts with baſis of earth, and all thoſe with metallic baſes, are capable of decompoſing ſoap, in the ſame manner as diſengaged acids are; with this difference, that the oil ſeparated from the fixed alkali, by the acid of theſe ſalts, may unite more or leſs intimately with the ſubſtance which was the baſis of the neutral ſalt employed for the decompoſition.

Soap may alſo be decompoſed by diſtillation; as Lemery has ſhewn. When firſt expoſed to fire, it yields a phlegm called by him a ſpirit; which nevertheleſs is neither acid nor alkaline, but ſome water which enters into the compoſition of ſoap. It becomes more and more coloured and empyreumatic as the fire is increaſed, which ſhews that it contains the moſt ſubtle part of the oil. It even ſeems, as Macquer remarks, to raiſe along with it by help of the oil, and action of the fire, a ſmall part of the alkali of the ſoap; for, as the ſame chemiſt obſerves, it occaſions a precipitate in a ſolution of corroſive ſublimate. But the modern diſcovery of the compoſition of volatile alkali leads us to infer, that the phlogiſticated air of part of the mucilage of the oil formed this ſalt, by uniting with the inflammable air in the heat of deſtructive diſtillation. See ALKALI VOLATILE. After this phlegm, the oil riſes altered, preciſely as if it had been diſtilled from quick-lime, that is, empyreumatic, ſoluble in ſpirit of wine, at firſt ſufficiently ſubtle, and afterwards thicker. An alkaline reſiduous coal remains in the retort, conſiſting chiefly of the mineral alkali contained in the ſoap, and which may be diſengaged from the coal by calcination in an open fire, and obtained in its pure ſtate.

As all oils contain an acid more or leſs combined, which may alſo be more or leſs diſengaged by the oil becoming rancid, by the action of heat, or by combination with other bodies, probably a portion of the alkali of the ſoap is ſaturated with the acid of the oil, eſpecially after the diſtillation of the ſoap. But this matter has not been ſo well examined, that we can affirm any thing concerning it.

Alkaline ſoaps are very uſeful in many arts and trades, and alſo in chemiſtry and medicine. Their principal utility conſiſts in a deterſive quality that they receive from their alkali, which, although it is in ſome meaſure ſaturated with oil, is yet capable of acting upon oily matters, and of rendering them ſaponaceous and miſcible with water. Hence ſoap is very uſeful to cleanſe any ſubſtances from all fat matters with which they happen to be ſoiled. Soap is therefore daily uſed for the waſhing and whitening of linen; for the cleanſing of woollen cloths from oil, and for whitening ſilk, and freeing it from the reſinous varniſh with which it is naturally covered. Pure alkaline lixiviums being capable of diſſolving oils more effectually than ſoap, might be employed for the ſame purpoſes; but when this activity is not mitigated by oil, as it is in ſoap, they are capable of altering, and even of deſtroying entirely by their cauſticity moſt ſubſtances, eſpecially animal matters, as ſilk, wool, and others: whereas ſoap cleanſes from oil almoſt as effectually as pure alkali, without danger of altering or deſtroying; which renders it very uſeful.

Volatile or eſſential oils are not united to alkaline ſalts but with great difficulty. Hence, according to Wiegleb, Starkey's ſoap is the only ſoap of this kind known. This ſoap is prepared by pouring four parts of oil of turpentine upon one of pulverized highly cauſtic fixed alkali in an alembic, digeſting them together for ſome time in a gentle heat, and laſtly, diſtilling the oil over the helm, and pouring it back again ſeveral times, till at length the ſalt will take up no more of it, and has acquired a ſaponaceous nature. With empyreumatic oils, a combination of this kind has not as yet ſucceeded; the formation of a ſoap of camphire however ſucceeded perfectly well.

Shorter methods have been ſought after for the preparation of Starkey's ſoap, by ſeveral chemiſts; and amongſt theſe is the illuſtrious Stahl; who, conſidering water as part of the combination of every ſoap, and even that it is a medium by which the ſalt and oil are united together, directs, that after having mixed oil of turpentine with very hot alkali, and having ſhook them together, this mixture ſhould be expoſed in a moiſt place, that all the portion of alkali which does not unite with the oil may deliquiate, and be ſeparated from the part of the mixture that is combined; that this alkali ſhould then be dried, and new oil poured upon it, as at firſt; and laſtly, that this method ſhould be continued till the whole be reduced into ſoap; and thus the operation will, as he affirms, be greatly ſhortened. Neverthelefs, later chemiſts, not ſatisfied with this method of Stahl, have endeavoured to ſimplify ſtill more this operation. Mr. Rouelle the younger has publiſhed, in the Journal de Medecine, that he has diſcovered a more expeditious method than all thoſe hitherto known for the preparation of this ſoap. Mr. Baumé has alſo publiſhed in the Gazette de Medecine a method of making it in a few hours. It conſiſts in triturating, during a long time, alkaline ſalt upon a porphyry, and in adding to this ſalt, during the trituration, oil of turpentine. According to this able chemiſt, the thick reſinous part only of this oil can truly combine with fixed alkali: and this combination is effected only while the more volatile and attenuated part of the oil is diſſipated. For which reaſon, according to him, a very great quantity of oil of turpentine is requiſite for the formation of Starkey's ſoap, which quantity of oil is indeterminate, as, the more volatile and ethereal it is, the more of it is required; and alſo the trituration upon the porphyry, by promoting the evaporation of the ſubtle part of the oil, accelerates conſiderably the operation of Starkey's ſoap.

Another artiſt ſays, in the Gazette de Medecine, that the operation may be much abridged, by adding to the new mixture a certain quantity of this ſoap ready made; which correſponds with Baumé's opinion. Laſtly, Baumé has found, that the addition of a little turpentine, or of ordinary ſoap, conſiderably

rably abridges the operation; and this alſo confirms his opinion, which ſeems to be very probable. Macquer has made ſeveral judicious obſervations on this compound.

He thinks this preparation ſeems to be uncertain, and ill choſen. For, beſides that the true ſoap of Starkey, that is, the intimate combination of ethereal oil of turpentine with fixed alkali, according to the uſual idea of it, is a thing probably impoſſible; it may be affirmed that the ſaponaceous compounds obtained by any method of mixing oil of turpentine with fixed alkali do not long remain in the ſame ſtate, and by time neceſſarily undergo perpetual alterations.

To be fully convinced of this truth, we may compare together not only theſe ſoaps made by different proceſſes, but alſo the ſame ſoap, a longer or ſhorter time after it has been made, and we ſhall find conſiderable differences in their colour, ſmell, and conſiſtence. We ſhall find that thoſe deliquiate, and are partly reſolved into liquor by the air, that have been made with a too ethereal oil, which is incapable of ſaturating well the fixed alkali; that others acquire by time a pitchy, yellowiſh, ſemi-tranſparent and reſinous appearance, which contain too large a quantity of thick reſiduum of oil of turpentine. Thoſe ſoaps which ſeem to be the beſt made, which contain a proper quantity of oil of turpentine, which are neither too ethereal nor too thick, preſerve longer their white colour and the conſiſtence of true ſoap: but they nevertheleſs participate more or leſs of the faults we have mentioned. Laſtly, all theſe ſoaps are liable to contain a conſiderable quantity of a ſort of neutral ſalt, formed by the acid of the oil of turpentine united with a part of the alkali of the ſoap. This ſalt cryſtallizes upon the ſurface, and even within the ſoap, which in time becomes quite penetrated and ſtuck all over with a ſaline effloreſcence. Theſe bad qualities and alterations of Starkey's ſoap cannot be avoided by any method, as they depend on the nature of eſſential oils, which we cannot change. Theſe ſoaps are known to contain a volatile and ſuperficially combined acid, which unfolds itſelf more and more, or which is engaged more intimately with a portion of oil, to which it gives a thicker conſiſtence. We are no leſs certain that the moſt ethereal part of eſſential oils, or their ſpiritus rector, is ſo volatile, that however attentive we may be to preſerve it, it will gradually diſſipate in time: in a word, we know from experience, that all eſſential oils are drying, and are much more ſpontaneouſly alterable than any others; and that theſe ſpontaneous alterations cannot be prevented by the imperfect combination which they are capable of forming with an alkali. On the contrary, this alkali, by abſorbing their acid, and by facilitating the diſſipation of their ethereal part, with which the alkali is not capable of forming a true union, can only haſten the alterations to which the oil is naturally diſpoſed.

From all this he concludes that Starkey's ſoap is a difficult, uncertain, variable preparation, which is continually changing its nature, and conſequently its medicinal virtues. This latter inconvenience, although it were the only one, would be ſufficient to make us reject this preparation. And therefore, as is probable, a ſaponaceous ſubſtance, partaking of the properties of fixed alkali and of an eſſential oil, would be uſeful in medicine; ordinary ſoap, incorporated extemporaneouſly with any quantity of eſſential oil which ſhall be judged proper, might be ſubſtituted inſtead of Starkey's ſoap.

Volatile alkali is in its nature but ill adapted for remaining fixed in bodies, till a perfect combination can take place with various kinds of fat; though in its cauſtic ſtate, by bare mixture alone, it imparts a ſaponaceous quality to lard, butter, and fat oils, inſomuch that they become ſoluble in ſpirit of wine. Conſequently it is only capable of uniting with volatile ethereal oils, from which concrete and fluid volatile oily ſalts are compounded. Of the former kind are the ſmelling-ſalts, or mild volatile alkali ſublimated with the addition of a fragrant or eſſential oil. Otherwiſe it may be expeditiouſly made, indeed extempore, by a mixture of three parts of purified alkali, one part of pure ſal ammoniac, and an addition of one or more parts of ſcented ethereal oils ad libitum, and kept in a phial well ſtopped. In the main too the ſalt of hartſhorn above deſcribed reſembles this. Of liquid volatile oily ſalts, the empyreumatic urinous ſpirits, Sylvius's volatile ſpirit (ſal volatile oleoſum Sylvii), likewiſe what is called Eau de luce, may be conſidered as inſtances. For the latter, Wiegleb directs that in two drams of the ſtrongeſt alcohol be diſſolved from ſix to ten drops of rectified oil of amber, and afterwards one ſcruple of white ſoap; to this mixture is then to be poured an ounce of the cauſtic volatile alkali, and the whole well ſhaken together. See Eau de Luce.

Metallic ſoaps, or combinations of the metallic calces with oils, are moſt expeditiouſly prepared by adding a ſolution of ſoap to a ſolution of the metal in an acid. The acid and the alkali unite, and the metallic calx forms in general an inſoluble combination with the oil, which therefore falls down. Fourcroy thinks that ſome of theſe might be uſeful as pigments.

Various other ſaponaceous bodies may be mentioned, which exhibit effects ſimilar to that of ſoaps upon ſubſtances and other bodies inſoluble in water, and make them at leaſt miſcible with it. This property ſugar exhibits with reſpect to ethereal oils, almonds in ſubſtance, the yolk of eggs, thick mucilage of gum arabic, gum tragacanth, the kernels of quinces, and mallow root, upon camphire, turpentine, wax, and different reſins; to effect which purpoſe, ſoap itſelf may be uſed with advantage.

SOAP STONE. See Lapis Ollaris.

SOAP-WORT. See Saponaria.

SODA. See Alkaline Mineral.

SOIL. See Arable Lands.

SOLDERS and SOLDERING. Solders conſiſt merely of ſimple or mixed metals, by which alone metallic bodies can be firmly united with each other. In this reſpect it is a general rule, that the ſolder ſhould always be eaſier of fuſion than the metal intended to be ſoldered by it: next to this, care muſt alſo be taken that the ſolder be as far as is poſſible of the ſame colour with the metal that is to be ſoldered.

For the ſimple ſolders, all the ſimple metals may be uſed according to the nature of the metal that is to be ſoldered. For fine ſteel, copper, and braſs work, gold and ſilver may be employed. In the large way, however, iron is ſoldered with copper, and copper and braſs with tin. The moſt uſual ſolders are the compound, which are diſtinguiſhed into two principal claſſes, viz. hard and ſoft ſolders. The hard ſolders are ductile, will bear hammering, and are commonly prepared of the ſame metal with that which is to be ſoldered, with the addition of ſome other; by which a greater degree of fuſibility is obtained, but which is not always required to be eaſier of fuſion. Under this head comes the hard ſolder for gold, which is prepared from gold and ſilver, or gold and copper, or gold, ſilver, and copper. The hard ſolder for ſilver is prepared from equal parts of ſilver and braſs, but made eaſier of fuſion by the admixture of a ſixteenth part of zinc. The hard ſolder for braſs is obtained from braſs mixed with a ſixth, or an eighth, or even one half of zinc, which may alſo be uſed for the hard ſolder or copper. It is ſold in the ſhops in a granulated form, under the name of Spelter Solder. The ſoft ſolders melt eaſily, but are partly brittle, and therefore cannot be hammered. Of this kind are the following mixtures: tin and lead in equal parts; of ſtill eaſier fuſion is that conſiſting of biſmuth, tin, and lead, equal parts; or of two parts of biſmuth, of tin and lead each one part.

In the operation of ſoldering, the ſurfaces of the metal intended to be joined muſt be made very clean, and applied to each other. It is uſual to ſecure them by a ligature of iron wire, or other ſimilar contrivance. The ſolder is laid upon the joint, together with ſal ammoniac or borax, or common glaſs, according to the degree of heat intended. Theſe additions defend the metal from calcination. Glaziers uſe reſin; and pitch is ſometimes employed.

Tin foil applied between the joints of fine braſs work, firſt wetted with a ſtrong ſolution of ſal ammoniac, makes an excellent juncture; care being taken to avoid too much heat.

SOLUTION. This word is uſed by chemiſts to denote the perfect union of a fluid ſubſtance with any other body. It is applied without diſtinction to the act of union, and to the compound reſulting from that act. The fluid is called the ſolvent, but no particular appellation has been given to the bodies diſſolved.

Solution is different from mere mechanical ſuſpenſion. One of its moſt diſtinguiſhing criterions is tranſparency in the compound. The act of ſolution being performed at the ſurfaces of bodies, will be more ſpeedy, the ſmaller the particles. Hence the advantage of pulverizing previous to ſolution. See ATTRACTION.

SONOROUSNESS. Daily experience ſhews that the ſounds emitted by various bodies when ſtruck are very different. On the nature of ſound, writers upon the mechanical philoſophy may be conſulted. The ſenſation is produced by a tremulous or vibratory motion communicated from the ſonorous body to the organ of the ear. The medium of communication ſeems to admit of no excluſion; but, as far as we yet know, the ſound is communicated to greater diſtances undiminiſhed, the denſer and perhaps the more elaſtic the ſubject of communication. Thus Dr. Franklin found that the ſtriking of two ſtones together under water was audible, with no apparent diminution, at the diſtance of two miles, by an obſerver whoſe head was plunged in the ſame continued maſs of water. And ſo likewiſe the ſcratching of a pin, or the beating of a watch, may be very diſtinctly heard from one end to the other of a piece of timber of any length, if the ear be applied cloſe to the timber, or if it be preſſed between the teeth, even though the ears be cloſed. The air of the atmoſphere is however the common medium of ſound. By experiments with ſtretched ſtrings, bells, and other muſical inſtruments, it is not only found that vibration is the cauſe of ſound, but the actual frequency of thoſe vibrations may be numerically aſcertained. Intenſity of ſound depends on the force of each vibration, and acuteneſs on their frequency. Hence the ſonorous qualities of bodies and other metals muſt depend in a great meaſure on their elaſticity, and conſiderably on their figure and denſity.

SOOT is a collection of ſubſtances formed by the matter of the flame of inflammable bodies, but which have eſcaped combuſtion from not having ſufficient contact with the air. This matter, which fixes itſelf to the internal ſurface of chimnies, is always of a black colour, more or leſs browniſh. This colour it receives from an oil that is burnt and half reduced to the ſtate of coal.

As all inflammable bodies undergo a total decompoſition during their inflammation, all the volatile principles which they contain, and even a part of the fixed principles, by means of thoſe which are volatile, are raiſed in vapours, ſome part of which burns with flame, is totally diſſipated in the elaſtic ſtate, and another part is ſublimed, and adheres to the firſt cold bodies which it meets.

Soot is, as we have now obſerved, the portion of fuel which is reduced to black ſmoke, and which has not been inflamed from want of ſufficient contact with air. For if the vapours exhaling from an inflammable body ſtrongly heated were ſo rarefied, that each of their parts ſhould be altogether ſurrounded by air, they would all burn with flame; and then we ſhould have no ſmoke or ſoot, or at leaſt this ſoot would not be black, and would contain nothing inflammable. For which reaſon the greater quantity of air is admitted amongſt bodies which burn with flame, the leſs ſmoke and ſoot we have; and alſo, the ſoot proceeding even from bodies of the ſame kind muſt be very different, according to the manner in which they are burnt. See Light. In general, we can ſay nothing that will be conſtantly applicable to the nature and principles of ſoot, as its differences ariſe not only from the cauſes above mentioned, but alſo from the nature of the inflammable ſubſtances which produce it. Thus vegetables, from which little or no volatile alkali is obtained, muſt furniſh a ſoot different from that of animal matters; and the ſoot of a pure oil muſt be different from that of a plant containing all its principles. But theſe differences have not yet been obſerved, becauſe chemiſts have not attended to this ſubject.

We know only that the ordinary ſoot of chimnies has an acrid, bitter, empyreumatic and diſagreeable taſte; that water can extract from it a duſky-coloured matter, which ſhews that it contains ſaline, oily, ſaponaceous parts; that it is capable of being again burnt very vividly and with much flame, as when chimnies are ſet on fire.

If this ſoot be diſtilled in a retort, we obtain from it phlegm, volatile alkali, partly concrete and partly liquid, a black empyreumatic oil, and in the retort much coal remains, from which fixed alkali may be extracted by incineration and lixiviation. Some acid alſo may poſſibly be obtainable from certain ſoots; and generally towards the end of the diſtillation, when the heat is ſtrong, a little ſal ammoniac is ſublimed.

As every ſoot, even that which proceeds from vegetable matters, contains a good deal of volatile alkali, Macquer infers that the principles of vegetables ſuffer by combuſtion in an open fire, changes ſimilar to thoſe occaſioned by putrefaction. Beſides, the quantity of fixed coal which remains after the diſtillation of ſoot, and which furniſhes a fixed alkali, together with much earth, by incineration, ſhews that a very conſiderable quantity of the fixed principles of inflammable bodies is carried off, and even raiſed to a great height, by means of their combuſtion with flame: but, as we have ſaid, ſoots are very different; and the matter is but little known, and requires further reſearches.

SORREL, SALT OF. For the purpoſe of preparing ſalt of wood-ſorrel, oxalis acetoſella Linn. the wood-ſorrel is bruiſed in a mortar, and the whole of its juice expreſſed. After it has ſtood for ſome time, the groſſer earthy particles ſubſide to the bottom, and the liquor becomes limpid and clear, after which it is filtered. The clear juice is then evaporated to leſs than one half, and ſet by in a cool place to cryſtallize. After ſome time, the remaining liquor is poured off from the cryſtals, and then evaporated, filtered, and cryſtallized afreſh. This proceſs is continued till the whole of the ſalt is extracted from the juice. According to Savary's experiments, fifty pounds of freſh wood-ſorrel yielded twenty-five pounds of juice, from which were obtained two ounces and a half of pure ſalt.

This ſalt conſiſts of a peculiar acid, which for this reaſon is called acid of wood-ſorrel, united to vegetable fixed alkali, as Wiegleb proved in an expreſs treatiſe on the ſubject. Conſequently it is a neutral ſalt, ſuperſaturated with acid. When it is combined with more alkali, ſo as to be ſaturated with it, peculiar neutral ſalts are produced by it. From the ſaturation of ſalt of wood-ſorrel with mineral alkali, Wenzel obtained a few ſmall cryſtals only, reſembling alum. The greater part of them ſhot up perpendicularly into the air, from the ſides of the veſſel; and preſerved indeed their form in the air, but were eaſily diſſolved in water. So that in this ſalt two different kinds of alkali were combined with the acid. Three hundred and ſeventy-ſeven grains of ſalt of ſorrel ſtill ſaturated two drachms of very dry mineral alkali with the redundant acid it contained. Salt of ſorrel ſaturated with the ordinary fixed alkali produced a neutral ſalt, which according to Wenzel partly concreted in long priſmatic cryſtals; though the greater part of the cryſtals were compoſed of large laminæ, lying one upon the other, with four, ſix, and more diſſimilar ſurfaces. Here, no more than two hundred and ninety-four grains of ſalt of wood-ſorrel were requiſite for ſaturating two drams of the ordinary alkali, with the redundant acid contained in them. According to Wiegleb's own experiments upon two different ſorts of ſalt of wood-ſorrel, half an ounce of one of them took four drams and a half of ſalt of tartar to ſaturate it, while the ſame quantity of the other required no more than three drams and a half. From the former ſort he obtained laminated, oblong, rhomboidal cryſtals, which had concreted one over the other, almoſt in the ſame manner as the ſalt of ſorrel itſelf. From the latter ſort he obtained a neutral ſalt, of which ſome of the cryſtals were extremely ſmall, and cohered together, while others were large, with rhomboidal ſurfaces, and pretty much reſembled borax. Theſe neutral ſalts precipitate the earth from ſpring water, and taſte almoſt like cryſtallized ſoluble tartar. Salt of ſorrel ſaturated with volatile alkali yields a peculiar ſalt, in which the pure acid is ſaturated with the ordinary fixed and the volatile alkali, and which, according to Wenzel, concretes into cryſtals in ſhape reſembling needles, and does not deliqueſce when expoſed to the open air.

Salt of ſorrel acts upon various ſubſtances without decompoſition. With ponderous earth, magneſia, vegetable alkali, and volatile alkali, it forms triple ſalts. Lime decompoſes it by ſeizing the whole of the acid, and diſengaging the alkali. The attraction of this acid for lime is ſo ſtrong, that it cannot be diſengaged from it by any other acid: another proceſs is therefore neceſſary to be uſed for obtaining it. With this intention, the ſuperabundant acid is to be ſaturated with volatile alkali; and into this ſolution muſt be poured a ſolution of ponderous earth in the nitrous acid. The laſt-mentioned acid combines with the alkalis, forming nitrous ammoniac and common nitre, both which remain in ſolution; while the ponderous earth, combining with the acid of ſorrel, forms an inſoluble compound which falls to the bottom. This precipitate, after being well waſhed, may be decompoſed by the addition of vitriolic acid, which ſeizes the earth, and likewiſe forms an inſoluble combination, while the acid is ſet at liberty. After decantation of the clear liquid, it muſt be aſſayed by pouring into it a little at a time of the boiling hot ſolution of ponderous earth in the acid of ſorrel. If there be any exceſs of vitriolic acid, a precipitate will be formed by its union with the ponderous earth. A due evaporation and cooling of this liquor afford the acid of ſorrel in priſmatic four-ſided cryſtals or ſquare plates. It is the ſame acid as that of ſugar. See Acid of Sugar.

For our knowledge of this ſalt, and the true nature and method of regenerating it by art, we are indebted to the immortal Scheele. The analogy of this ſalt with the acid of ſugar induced him to examine it farther; and after a few unſucceſsful attempts, he diſcovered the mode of regenerating it. Having diſſolved as much acid of ſugar in cold water, as the water could take up, he added to this ſolution ſome lixivium of tartar, drop by drop, waiting a little after each drop; and found the mixture, during the effervescence, full of ſmall cryſtals, which were genuine ſalt of wood-ſorrel. The identity of the acid of wood-ſorrel with that of ſugar has not only been proved by Scheele himſelf, but by ſeveral other chemiſts, particularly Mr. Klaproth of Berlin, by means of a very curious and ſtriking experiment. This gentleman precipitated a ſolution of quickſilver in nitrous acid, with ſalt of wood-ſorrel perfectly neutralized by vegetable alkali, and obtained a white precipitate, which when edulcorated and dried, and gently heated in a tea-ſpoon, produced a fulminating noiſe not inferior to that of fulminating gold. Acid of ſugar, perfectly neutralized with vegetable alkali, afforded the ſame precipitate, and exhibited the ſame fulminating power. Hence they are now very properly confounded together.

SOUP. See GELLY.

SPAR. Naturaliſts and chemiſts have given this name to certain cryſtallized ſtones, more or leſs tranſparent, which generally do not ſtrike fire with ſteel, and which are found plentifully within the earth, but more eſpecially in mines of metals.

Under this general name many ſtones are comprehended; becauſe they have the general properties we have mentioned, and becauſe they reſemble each other by the form of their cryſtallization, in which we always perceive ſhining plates, like mirrors; but ſome of theſe ſtones are very different from others.

Some ſpars are entirely ſoluble with effervescence in acids, forming ſelenites with vitriolic acid, deliqueſcent ſalts with nitrous and marine acids, and being convertible into quick-lime by calcination. Theſe ſtones are juſtly called calcareous ſpars. They conſiſt of lime and fixed air.

Others, although entirely ſimilar to theſe in appearance, do not effervesce with acids, are calcinable as gypſum and ſelenites are, and are in fact true ſelenites compoſed of vitriolic acid and calcareous earths. Theſe ſpars are eſſentially different from the former, and are gypſeous or ſelenitic ſpars. They conſiſt of lime and vitriolic acid.

Other ſpars are neither calcareous nor ſelenitic, do not loſe their tranſparency in the fire, and ſeem to be of the nature of talc. See the article. The word ſpar is ſeldom applied to talcs at preſent.

Laſtly, a kind of ſtone, cryſtallized in mirror-like plates, like a true ſpar, almoſt opake, indiſſoluble by acids, and ſo much harder than all other ſpars as to be capable of ſtriking fire with ſteel. This ſtone is fuſible without addition, by the action of a violent fire, into a ſemi-tranſparent white matter. It ſeems to be the kind that Wallerius, Pott, and other German authors, call fuſible ſpars. They alſo mention another ſpar, which is compact, breaks like glaſs, and melts without addition.

From the deſcriptions given by moſt authors, we cannot eaſily diſcover what they mean by fuſible ſpar, and by quartz-ſpar. Theſe matters have not yet been ſufficiently examined.

From the properties of all the ſubſtances called ſpars, it may be inferred that they are ſtones of all kinds, very different from each other, which being formed in metallic grounds, have contracted, either by the mixture of ſome metallic earths, or otherwiſe, ſome properties common to all, or, at leaſt, to the greateſt number.

Theſe properties enumerated by Macquer are, 1. A certain form of ſhining laminæ in their cryſtallization, which appears even in thoſe the figure of whoſe cryſtals ſeems leaſt diſpoſed to receive this form, as in thoſe which are ſtriated; for ſparry laminæ are diſtinguiſhable at the extremities of the ſtriæ, or bundles of ſtriæ, of which theſe ſpars are compoſed.

2. A greater ſpecific gravity than of other ſtones. Some ſpars, eſpecially thoſe called heavy ſpars, are ſo very heavy, that they come near in this reſpect to metals.

3. A greater fuſibility than of other ſtones; for, beſides theſe ſpars which are fuſible without addition, the mixture of ſpars facilitates the fuſion of moſt other earths and ſtones, and they are accordingly uſed as fluxes in the ſmelting of moſt metallic ores. Probably for this reaſon, theſe ſtones have been called fluors by many mineralogiſts and metallurgiſts.

Laſtly, many ſpars are found coloured by metallic matters, and reſemble the ſeveral precious ſtones, though they are leſs beautiful and vivid.

To the above paſſages of Macquer his annotator adds the following, which I have altered in a few places.

The name of ſpar is given to many ſtones of different properties and appearances, which do not poſſeſs conſtantly any one common character or mark by which they may be certainly diſtinguiſhed from other ſtones. In general, we may obſerve, that they are moſt frequently found in mines, and that they for the moſt part conſiſt of ſmooth and ſhining plates or laminæ; that ſome are tranſparent, and others opake; that ſome are colourleſs, and others are coloured; that they are cryſtallized in various determinate figures, or poſſeſs no determinate ſhape; and laſtly, that they differ ſo much in hardneſs, denſity, degree of fuſibility, and in their moſt eſſential chemical properties, that they cannot be conſidered as forming a diſtinct claſs of foſſil ſubſtances. We need not wonder therefore, that authors, eſpecially thoſe who have not been much accuſtomed to the examination of foſſil bodies, ſhould have given very confuſed and indiſtinct deſcriptions of ſpars. Many of them have not been ſufficiently examined; but thoſe of which we have acquired ſome knowledge we ſhall endeavour to diſtinguiſh into their ſeveral different kinds.

The ſeveral ſtones to which the name of ſpar has been given are, the calcareous, the ponderous, the gypſeous, the fluors, and felt ſpar.

1. Calcareous ſpars are ſoft, heavy ſtones, which have the common chemical properties of calcareous earth. Their texture is laminated. Some of them have no determinate figure, and others from their form are called rhomboidal. Some ſpars, called dog's-tooth ſpar, have a pyramidal figure; but when theſe are broken, their fragments ſhew that they alſo conſiſt of rhomboidal particles.

Some rhomboidal ſpars are tranſparent, others are opake; ſome are colourleſs, and others are coloured; laſtly, ſome of them have a ſingular property of refracting doubly the rays of light which paſs through them, and thereby of repreſenting any object; as for inſtance, the letters of a book, ſeen through it, double. This ſpar has been called iſland cryſtal, or refracting ſpar. Its figure is that of an oblique parallelopiped, contained within ſix parallelogrammic ſides, and eight ſolid angles. Each of the obtuſe angles of the parallelograms is 101 degrees and 52 minutes; and each of the acute angles is 78 degrees and 8 minutes. Theſe are the dimenſions given by Sir Iſaac Newton of the angles of the ſides of the refracting ſpar.

Calcareous ſpars may be diſtinguiſhed from others by effervefcing with acids.

2. Gypſeous or ſelenitic ſpars. Theſe are vitriolated lime, diſtinctly cryſtallized. The form of the cryſtals is rhomboidal. They are alſo called ſelenites and glacies Mariæ. Sometimes theſe ſpars aſſume other forms.

3. The ponderous ſpars are compounds of the ponderous earth, either with fixed air or vitriolic acid. The firſt of theſe, which was diſcovered by Dr. Withering, as mentioned under the article Earth Ponderous, uſually reſembles alum, and affects a fibrous cryſtallization diverging from a centre. It has the ſemi-tranſparency and appearance of alum. The native ſpecimen examined by Dr. Withering contained 20,8 parts of fixed air, 78,6 of ponderous earth, and the remainder the vitriolic ponderous ſpar, without any water. In this laſt reſpect it differs much from the aerated ponderous earth of Bergman, which he obtained by precipitation from its ſolvent by mild alkali. This contained 28 parts water, 7 fixed air, and 65 ponderous earth. The fixed air of the artificial compound could be expelled by heat. But that of the natural ſpar adhered ſo ſtrongly, probably on account of the abſence of water, that it underwent fuſion rather than part with it. This ſpar, as well as the vitriolic, is eminently diſtinguiſhable by its great ſpecific gravity, which amounts to 4,338, and is emulated by no other unmetallic earth but the adamantine ſpar, which is very ſcarce, at leaſt in Europe.

The common ponderous ſpar, or compound of ponderous earth and vitriolic acid, has been called marmor metallicum, ſpar-like gypſum, Bononian ſtone, and baroſelenite. It is found with various degrees of tranſparency, from perfect clearneſs to opacity. Of the regularly cryſtallized ſort, Mr. Thompſon ſhewed Magellan ſome fine ſpecimens, and remarked, that it ſeems to affect the peculiarity of having its cryſtals laminated, as radiating from a centre: but this radiation ſeldom amounts to a whole circle. The corners of theſe flat cryſtals are truncated, like thoſe of alum, and are thicker in one ſide than in the other of each parallelogram, ſo as to fit one another in the arch of the kind of vault they form together; and have ſome ſmall ones adhering to their ſides, like druſen ſpars, leaving internal angles, as the macles of the French, or the cruciform cryſtallizations. In ſeveral of the cryſtals preſented to me by that active cultivator of the ſciences, the general outline was that of a right-angled parallelogram, and the principal truncatures, namely of the corners, formed angles of 45 degrees. The internal fiſſures, which reſembled thoſe of the common calcareous ſpar, have likewiſe this poſition with reſpect to each other; which circumſtance joined to that of their great weight appeared to be diſtinctive criterions of this ſubſtance. The ſpecific gravity of theſe cryſtals proved to be 4,75.

The opake cryſtals are either white, or reddiſh, from a ſlight admixture of iron.

The opake fawn coloured ſpecimens of vitriolated ponderous earth, known by the name of cauk, are common, and affect the peculiar figure of an aſſemblage of ſmall convex lenſes ſet together edgeways. This is generally diſtinguiſhed by the name criſtated by mineralogiſts. Its ſpecific gravity is ſcarcely inferior to that of the tranſparent ſpecimens.

4. Fluors. Of the ſpars called fluors, we have treated under the article Fluor.

5. Adamantine ſpar. See the article. Dr. Combe ſhewed me a piece of ſtone

from the Eaſt-Indies, of remarkable hardneſs, ſuppoſed to be uſed in poliſhing jewels. Its whole figure was ſuch as art had left it. Two ſides were flat, apparently from having been ſawed with diamond duſt. It had the appearance of being part of a larger plate. Its thickneſs was about a quarter of an inch, the flat ſides were unpoliſhed; but a number of ſmall ſpherical poliſhed concavities had been made in thoſe ſurfaces, for ſome uſe about which I received no information. Its colour was of a dark green, like bottle-glaſs, ſo dark as to appear almoſt opake. When held to the light, ſome cloudy ſtrait ſtreaks were ſeen within it, reſembling thoſe of certain ſpars, and ſome agates. It had one ſhake or flaw acroſs the direction of the parallel ſtreaks, and on the whole was evidently a natural production. It very eaſily marked agate, quartz and other hard ſtones, and is ſaid to yield in hardneſs only to the diamond, which I found ſcratched it without any difficulty. Its weight was 89,2 grains, and it loſt by immerſion in water 22,25 grains. Whence its ſpecific gravity is deduced 4,09.

SPECIFIC GRAVITY. See GRAVITY SPECIFIC.

SPECULARIS LAPIS, a name occaſionally given to the clear vitriolated lime, or gypſeous ſpar.

SPECULUM. When tin is melted with copper, it compoſes the compound called bronze. In this metal the ſpecific gravity is always greater than would be deduced by computation from the quantities and ſpecific gravities of its component parts. The uſes of this hard, ſonorous, and durable compoſition, in the fabrication of cannon, bells, ſtatues, and other articles, are well known. Bronzes and bell-metals are not uſually made of copper and tin only, but have other admixtures, conſiſting of lead, zinc, or arſenic, according to the motives of profit, or other inducements of the artiſt. But the attention of the philoſopher is more particularly directed to the mixture of copper and tin, on account of its being the ſubſtance of which the ſpeculums of reflecting teleſcopes are made. The metal required for this purpoſe ought to be capable of an exquiſite poliſh, hard enough to receive and retain a figure accurately ſuited to the regular reflection of light, and not ſubject to become tarniſhed by the action of the atmoſphere. Many excellent teleſcopes have been made with compoſitions of pure copper, alloyed with ſomewhat leſs than half its weight of tin. But it appears to be very well aſcertained, from the obſervations of the aſtronomer royal, that the ſpeculums of Mr. Edwards, whoſe compoſition was the reſult of numerous trials, are much ſuperior to any which have yet been made, and are even equal in light to acromatic teleſcopes of the ſame aperture, without altering the colours of objects. He firſt melts 32 parts of copper as fluid as poſſible, with one part of braſs, and one of ſilver, together with the black flux; at the ſame time that 15 parts of tin are melted in a ſeparate crucible. Theſe being taken from the fire, he pours the tin to the copper; immediately ſtirs the whole together with a wooden ſpatula, and pours it out haſtily into a large quantity of cold water, which cools and granulates the compoſition. If the tin were fuſed together with the copper, or if they were to remain for any length of time in the extreme heat which is neceſſary to fuſe this laſt metal, a part of the tin would be calcined, and the metal would abound more or leſs with ſmall microſcopic pores. If one of the pieces of the cold metal be broken, it will appear of a moſt beautiful bright colour, reſembling quickſilver. Mr. Edwards affirms, that different kinds of copper require different doſes of tin to produce the moſt perfect whiteneſs. If the doſe of tin be too ſmall, which is the fault moſt eaſily remedied, the compoſition will be yellowiſh; if it be too great, the compoſition will be of a gray blue colour, and dull appearance. He therefore finds by trial the quantity of tin neceſſary to be added in the ſecond fuſion to render the metal the moſt perfect. A much leſs degree of heat is then required to melt the compound. In the ſecond melting he adds one part of arſenic, and immediately ſtirs the mixture; which he pours into the mould as ſoon as the fumes of the arſenic have ceaſed to riſe. He caſts the ſpeculum in ſand, with the face downwards; takes it out while red-hot, and places it in hot wood aſhes to cool; without which precaution it would break in cooling.

As the conſtruction of teleſcopes is foreign to the immediate purpoſe of this work, it has not been thought neceſſary to mention the ſeveral precautions of Mr. Edwards in this buſineſs; but the curious operator, who may wiſh to undertake the conſtruction of a reflecting teleſcope (the better kinds of which are not only difficult to be procured, but of conſiderable price), may have recourſe to Edwards's treatiſe, annexed to the Nautical Almanack for 1787; where he will find ample inſtructions for that purpoſe.

The compoſition of metal for ſpeculums, previous to the invention of the reflecting teleſcope, was in the hands of artiſts, and did not require that extreme perfection with regard to denſity and other properties, which the ſpecula of thoſe inſtruments demand. Experience ſhewed them that arſenic is a valuable ingredient in theſe mixtures; but ſpeculative philoſophers, reaſoning from the ſaline property of that ſubſtance before it was known that it can be reduced to a metallic regulus, were apprehenſive that it would increaſe the diſpoſition to tarniſh. I conjecture that Mr. Edwards's compoſition might be improved by a greater proportion of arſenic, or at leaſt by adding this ingredient in an earlier ſtage of the proceſs. For this reaſon, I ſhall here inſert the directions which Blancourt* in his Art of Glaſs gives, as the beſt of all compoſitions for whiteneſs, hardneſs, and ſuſceptibility of an exceeding fine poliſh. As I do not anſwer for the value of this receipt, I ſhall give it in the author's own words, after remarking that the oil of tartar is evidently unneceſſary; that the gradual management of the heat on a ſand bath, is probably a uſeleſs refinement; that the ſubſtitution of orpiment for arſenic, as he recommends, muſt be noxious; that by latten I underſtand common braſs, of which there are various kinds; and that the addition of the tin ſhould be made in the fuſed ſtate.

Take plates of copper, one pound, mince them that they may be put into a crucible, imbibing them with oil of tartar; then powder a quarter of a pound of white arſenic, and put theſe S. S. S. as we have ſhewn the method elſewhere, until you fill the crucible; pour on them afterwards linſeed-oil to cover the arſenic and the copper; head and lute your crucible; and when the lute is dry, ſet it on a ſand furnace, letting the ſand ariſe no higher than the head; heat the furnace gently till it arrive at a juſt degree, and the oil begins to evaporate; by this time the oil will prepare the copper for retaining the arſenic, which muſt enter the copper as eaſily as oil does leather; ſet it again on freſh ſand, and increaſe the heat of the furnace, giving it the ſame degree as before, until the oil evaporate and boil up; then take off the crucible, let it cool, and break it, you will find your copper of ſeveral colours, and would be much better, if inſtead of arſenic you made uſe of orpiment.

Take of this copper one part, of latten two parts, melt the latten on a ſmart fire, and ſo put in the copper; when they are well melted, caſt the metal drop by drop into a glazed earthen veſſel full of water, over which lay a buſh or broom for the ſtuff to go through; thus you will have a metal not to be touched with a file, nor brittle, as good as any ſteel for all uſes whatſoever.

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* Engliſh Tranſlation, London 1699.

Take of this hard metal, three parts, and beſt tin of Cornwall, which has no lead in it, one part; melt the metal before you put in the tin; after theſe are well incorporated, you may fill your moulds, &c.

SPEISS. The Bohemian name for miſpickel, which ſee.

SPELTER. Zinc is called ſpelter in commerce. The ſoft braſs containing a redundant proportion of zinc, and ſold in the granulated form for the uſe of artiſts in ſoldering, is called ſpelter ſolder, and frequently ſpelter only.

SPERMACETI. The brain of a ſpecies of whale, purified from the oily matter, affords a fat of a ſingular kind, known in the ſhops by the improper name of ſpermaceti.

The ſpermaceti whale, called cetus dentatus, and orca, and by the Engliſh ſailors employed in the Greenland-fiſhery, torump, jubart, or gibbart, is ſmaller than the common whale, but the head is proportionably much larger, amounting to above one-third the bulk of the whole body. He is furniſhed with teeth, which the other is not; and wants the flexible bones in the mouth, called whale-bone, which the other has. The throat is alſo remarkably wider.

One of theſe fiſhes affords ſome tons of brains, which are firſt groſſly freed from the oil by draining and preſſing, and afterwards more perfectly purified by ſteeping them in a ley of alkaline ſalt and quick-lime, which diſſolves the remains of the oily matter into a ſaponaceous liquid. The brains, being then waſhed with water, appear of a ſilver whiteneſs; and nothing more is required to complete the preparation than to cut them in ſhivers with wooden knives, and ſpreading them abroad to dry. Such is the ſimple proceſs, by which this profitable commodity is prepared. It has been ſaid that ſpermaceti is a natural concrete, found floating on the ſurface of the northern ſeas; but this is plainly a falſe report, perhaps calculated to prevent enquiry into the manner of its preparation.

Good ſpermaceti is in fine white flakes, gloſſy and ſemi-tranſparent, ſoft and unctuous to the touch, yet dry and eaſily friable, in taſte ſomewhat like butter, of a faint ſmell like that of tallow.

It is apt in keeping, if not carefully ſecured from the air, to grow yellowiſh, and contract a rancid fiſhy ſmell. The more perfectly it has been purified at firſt, the leſs ſuſceptible it is of theſe alterations; and after it has been ſo changed, it may be reduced white and ſweet again, by ſteeping it afreſh in a ley of alkaline ſalt and quick-lime.

It melts in a ſmall degree of heat, and congeals again as it cools. Laid on burning coals, it emits a fetid ſmell, like that of the ſnuff of a candle. The contact of flame does not ſet it on fire, but with a wick it burns equally with common tallow-candles.

In diſtillation it totally ariſes, leaving no coal or caput mortuum behind; from four ounces were obtained three ounces and a half of oil, and a dram and a half of phlegm; the other two drams and a half having been waſted or diſſipated in the proceſs. The oil is not a brown or black fetid empyreumatic one, like thoſe of other animal ſubſtances; but clear, yellowiſh, of a butyraceous conſiſtence, in ſmell like oil of wax, like which alſo it coagulates in the cold.

Rectified ſpirit of wine, digeſted and boiled with ſpermaceti, takes up about half a dram out of half an ounce; the greateſt part ſettles to the bottom, and the finer particles float in the liquor, in appearance like flowers of benzoine.

Water long digeſted or boiled with it extracts nothing. By grinding it with ſugar or almonds, it becomes miſcible with water, but not near ſo perfectly as the vegetable reſins do by the ſame treatment; on ſtanding for a little time, the ſpermaceti ſeparates and floats on the ſurface. Yolks of eggs unite it more thoroughly with watery liquors: but when diſſolved by theſe alſo, it ſoon ſeparates and falls to the bottom.

Even cauſtic alkaline ley does not diſſolve nor unite with it into ſoap, as it does with all other fats; and hence the uſe of this ley in its preparation and purification. It mingles ſufficiently with oils, fats, balſams, reſins, butter, wax, &c.

It has been conjectured that this ſingular ſubſtance bears the ſame relation to fat oils as camphor does to the eſſential oils. Wax appears to have the ſame relation to fixed oils as reſin has to the eſſential; that is to ſay, both have been rendered concrete by the abſorption of vital air. But ſpermaceti and camphor ſeem to differ in ſome other leading particular; probably in the abſence of acid, or of any baſis which can eaſily be acidified by the action of nitrous or other acids. Much information would no doubt be derived from a careful examination of the products which theſe ſeveral ſubſtances afford by combuſtion.

Excellent candles are made from ſpermaceti, in thoſe places where it is prepared, at Bayonne, at St. Jean-de-Luz, &c. In England there are many manufactories of theſe candles; and within theſe few years ſome ſuch have been eſtabliſhed at Paris.

Spermaceti appears to be a medium between wax and tallow, with reſpect to the advantages derived from it with a thin wick. See LIGHT.

The nitrous and the muriatic acids are incapable of acting on this ſubſtance. The concentrated ſulphuric acid diſſolves it, and at the ſame time alters its colour: this ſolution is precipitated by water, like oil of camphor.

It combines with ſulphur like fixed oils. Hot alcohol diſſolves it as well as fixed and volatile oils, but ſuffers it to precipitate by cooling. Æther effects this ſolution cold, or at leaſt without the help of a greater heat than the natural warmth of the hand.

The attention of chemiſts has been greatly excited by the ſpontaneous converſion of animal matter into a ſubſtance of the ſame nature as ſpermaceti. The fact has long been well known, and is ſaid to have been mentioned in the works of Lord Bacon, though I have not ſeen the paſſage. On the occaſion of the removal of a very great number of human bodies from the ancient burying-place Des Innocens at Paris, facts of this nature were obſerved in the moſt ſtriking manner. M. De Fourcroy may be called the ſcientific diſcoverer of this peculiar matter, as well as the ſaponaceous ammoniacal ſubſtance contained in bodies abandoned to ſpontaneous deſtruction in large maſſes. This chemiſt read a Memoir on the ſubject in the year 1789 to the Royal Academy of Sciences, from which I ſhall abſtract the general contents *.

At the time of clearing the before mentioned burying-place, certain philoſophers were ſpecially charged to direct the precautions requiſite for ſecuring the health of the workmen. A new and ſingular object of reſearch preſented itſelf, which had been neceſſarily unknown to preceding chemiſts. It was impoſſible to foretell what might be the contents of a ſoil overloaded for ſucceſſive ages

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* Annales du Chimie, v. 154.

with bodies reſigned to the putrefactive proceſs. This ſpot differed from common burying-grounds, where each individual object is ſurrounded by a portion of the ſoil. It was the burying-ground of a large diſtrict, wherein ſucceſſive generations of the inhabitants had been depoſited for upwards of three centuries. It could not be foreſeen that the entire decompoſition might be retarded for more than forty years; neither was there any reaſon to ſuſpect that any remarkable difference would ariſe from the ſingularity of ſituation.

The remains of the human bodies immerſed in this maſs of putreſcence were found in three different ſtates, according to the time they had been buried, the place they occupied, and their relative ſituations with regard to each other. The moſt ancient were ſimply portions of bones, irregularly diſperſed in the ſoil, which had been frequently diſturbed. A ſecond ſtate, in certain bodies which had always been inſulated, exhibited the ſkin, the muſcles, tendons and aponeuroſes, dry, brittle, hard, more or leſs gray, and ſimilar to what are called mummies in certain caverns where this change has been obſerved, as in the catacombs at Rome, and the vault of the Cordeliers at Toulouſe.

The third and moſt ſingular ſtate of theſe ſoft parts was obſerved in the bodies which fill the common graves or repoſitories. By this appellation are underſtood cavities of thirty feet in depth and twenty on each ſide, which were dug in the burying-ground of the Innocents, and were appropriated to contain the bodies of the poor; which were placed in very cloſe rows, each in its proper wooden bier. The neceſſity for diſpoſing a great number obliged the men charged with this employment to arrange them ſo near each other, that theſe cavities might be conſidered when filled as an entire maſs of human bodies, ſeparated only by two planks of about half an inch thick. Each cavity contained between one thouſand and fifteen hundred. When one common grave of this magnitude was filled, a covering of about one foot deep of earth was laid upon it, and another excavation of the ſame ſort was made at ſome diſtance. Each grave remained open about three years, which was the time required to fill it. According to the urgency of circumſtances, the graves were again made on the ſame ſpot after an interval of time not leſs than fifteen years, nor more than thirty. Experience had taught the workmen that this time was not ſufficient for the entire deſtruction of the bodies, and had ſhewn them the progreſſive changes which form the object of M. Fourcroy's Memoir.

The firſt of theſe large graves opened in the preſence of this chemiſt had been cloſed for fifteen years. The biers or coffins were in good preſervation, but a little ſettled, and the wood (I ſuppoſe deal) had a yellow tinge. When the covers of ſeveral were taken off, the bodies were obſerved at the bottom, leaving a conſiderable diſtance between their ſurface and the cover, and flattened as if they had ſuffered a ſtrong compreſſion. The linen which had covered them was ſlightly adherent to the bodies; and, with the form of the different regions, exhibited on removing the linen nothing but irregular maſſes of a ſoft ductile matter of a gray white colour. Theſe maſſes environed the bones on all ſides, which had no ſolidity, but broke by any ſudden preſſure. The appearance of this matter, its obvious compoſition and its ſoftneſs, reſembled common white cheeſe; and the reſemblance was more ſtriking from the print which the threads of the linen had made upon its ſurface. This white ſubſtance yielded to the touch, and became ſoft when rubbed for a time between the fingers.

No very offenſive ſmell was emitted from theſe bodies. The novelty and ſingularity of the ſpectacle, and the example of the grave-diggers, diſpelled every idea either of diſguſt or apprehenſion. Theſe men aſſerted that they never found this matter, by them called *gras* (fat), in bodies interred alone; but that the accumulated bodies of the common graves only were ſubject to this change. On a very attentive examination of a number of bodies paſſed to this ſtate, M. Fourcroy remarked that the converſion appeared in different ſtages of advancement, ſo that, in various bodies, the fibrous texture and colour, more or leſs red, were diſcernible within the fatty matter; that the maſſes covering the bones were entirely of the ſame nature, offering indiſtinctly in all the regions a gray ſubſtance for the moſt part ſoft and ductile, ſometimes dry, always eaſy to be ſeparated in porous fragments, penetrated with cavities, and no longer exhibiting any traces of membranes, muſcles, tendons, veſſels, or nerves. On the firſt inſpection of theſe white maſſes, it might have been concluded that they were ſimply the cellular tiſſue, the compartments and veſicles of which they very well repreſented.

By examining this ſubſtance in the different regions of the body, it was found that the ſkin is particularly diſpoſed to this remarkable alteration. It was afterwards perceived that the ligaments and tendons no longer exiſted, or at leaſt had loſt their tenacity; ſo that the bones were entirely unſupported, and left to the action of their own weight. Whence their relative places were preſerved in a certain degree by mere juxta-poſition; the leaſt effort being ſufficient to ſeparate them. The grave-diggers availed themſelves of this circumſtance in the removal of the bodies. For they rolled them up from head to feet, and by that means ſeparated from each other the extremities of the bones which had formerly been articulated. In all theſe bodies which were changed into the fatty matter the abdominal cavity had diſappeared. The teguments and muſcles of this region being converted into the white matter like the other ſoft parts, had ſubſided upon the vertebral column, and were ſo flattened as to leave no place for the viſcera, and accordingly there was ſcarcely ever any trace obſerved in the almoſt obliterated cavity. This obſervation was for a long time matter of aſtoniſhment to the inveſtigators. In vain did they ſeek in the greater number of bodies the place and ſubſtance of the ſtomach, the inteſtines, the bladder, and even the liver, the ſpleen, the kidneys, and the matrix in females. All theſe viſcera were confounded together, and for the moſt part no traces of them were left. Sometimes only certain irregular maſſes were found, of the ſame nature as the white matter, of different bulks, from that of a nut to two or three inches in diameter, in the regions of the liver or of the ſpleen.

The thorax likewiſe offered an aſſemblage of facts no leſs ſingular and intereſting. The external part of this cavity was flattened and compreſſed like the reſt of the organs; the ribs, ſpontaneouſly luxated in their articulations with the vertebræ, were ſettled upon the dorſal column; their arched part left only a ſmall ſpace on each ſide between them and the vertebræ. The pleura, the mediaſtines, the large veſſels, the aſpera arteria, and even the lungs and the heart, were no longer diſtinguiſhable; but for the moſt part had entirely diſappeared, and in their place nothing was ſeen but ſome parcels of the fatty ſubſtance. In this caſe, the matter which was the product of decompoſition of the viſcera, charged with blood and various humours, differs from that of the ſurface of the body, and the long bones, in the red or brown colour poſſeſſed by the former. Sometimes the obſervers found in the thorax a maſs irregularly rounded of the ſame nature as the latter, which appeared to them to have ariſen from the fat and fibrous ſubſtance of the heart. They ſuppoſed that this maſs, not conſtantly found in all the ſubjects, owed its exiſtence to a ſuperabundance of fat in this

viſcus,

viſcus, where it was found. For the general obſervation preſented itſelf, that in ſimilar circumſtances, the fat parts undergo this converſion more evidently than the others, and afford a larger quantity of the white matter.

The external region in females exhibited the glandular and adipoſe maſs of the breaſts converted into the fatty matter very white and very homogeneous.

The head was, as has already been remarked, environed with the fatty matter; the face was no longer diſtinguiſhable in the greateſt number of ſubjects; the mouth diſorganized exhibited neither tongue nor palate, and the jaws, luxated and more or leſs diſplaced, were environed with irregular layers of the white matter. Some pieces of the ſame matter uſually occupied the place of the parts ſituated in the mouth; the cartilages of the noſe participated in the general alteration of the ſkin; the orbits inſtead of eyes contained white maſſes; the ears were equally diſorganized; and the hairy ſcalp having undergone a ſimilar alteration to that of the other organs, ſtill retained the hair. M. Fourcroy remarks incidentally that the hair appears to reſiſt every alteration much longer than any other part of the body. The cranium conſtantly contained the brain contracted in bulk; blackiſh at the ſurface, and abſolutely changed like the other organs. In a great number of ſubjects which were examined this viſcus was never found wanting, and it was always in the above-mentioned ſtate; which proves that the ſubſtance of the brain is greatly diſpoſed to be converted into the fat matter.

Such was the ſtate of the bodies found in the burial ground Des Innocens. Its modifications were alſo various. Its conſiſtence in bodies lately changed, that is to ſay, from three to five years, was ſoft and very ductile; containing a great quantity of water. In other ſubjects converted into this matter for a long time, ſuch as thoſe which occupied the cavities which had been cloſed thirty or forty years, this matter is drier, more brittle and in denſer flakes. In ſeveral which were depoſited in dry earth, various portions of the fatty matter had become ſemi-tranſparent. The aſpect, the granulated texture, and brittleneſs of this dried matter, bore a conſiderable reſemblance to wax.

The period of the formation of this ſubſtance had likewiſe an influence on its properties. In general, all that which had been formed for a long time was white, uniform, and contained no foreign ſubſtance, nor fibrous remains; ſuch in particular was that afforded by the ſkin of the extremities. On the contrary, in bodies recently changed, the fatty matter was neither ſo uniform nor ſo pure as in the former; but it was ſtill found to contain portions of muſcles, tendons, and ligaments, the texture of which, though already altered and changed in its colour, was ſtill diſtinguiſhable. Accordingly, as the converſion was more or leſs advanced, theſe fibrous remains were more or leſs penetrated with the fatty matter, interpoſed as it were between the inteſtices of the fibres. This obſervation ſhews that it is not merely the fat which is thus changed, as was natural enough to think at firſt ſight. Other facts confirm this aſſertion. The ſkin, as has been remarked, becomes eaſily converted into very pure white matter, as does likewiſe the brain, neither of which have been conſidered by anatomiſts to be fat. It is true nevertheleſs, that the unguinous parts, and bodies charged with fat, appear more eaſily and ſpeedily to paſs to the ſtate under conſideration. This was ſeen in the marrow, which occupied the cavities of the longer bones. And again, it is not to be ſuppoſed, but that the greater part of theſe bodies had been emaciated by the illneſs which terminated their lives; notwithſtanding which, they were all abſolutely turned into this fatty ſubſtance.

An experiment made by M. Poulletier De la Salle and Fourcroy likewiſe evinced that a converſion does not take place in the fat alone. M. Poulletier had ſuſpended in his laboratory a ſmall piece of the human liver, to obſerve what would ariſe to it by the contact of the air. It partly putrefied, without however emitting any infectious ſmell. Larvæ of the Dermeſtes, and Bruches attacked and penetrated it in various directions; at laſt it became dry, and after more than ten years ſuſpenſion, it was converted into a white friable ſubſtance reſembling dried agaric, which might have been taken for an earthy ſubſtance. In this ſtate, it had no perceptible ſmell. M. Poulletier was deſirous of knowing the ſtate of this animal matter, and experiment ſoon convinced him and M. F. that it was very far from being in the ſtate of an earth. It melted by heat, and exhaled in the form of vapour, which had the ſmell of a very fetid fat; ſpirit of wine ſeparated a concreſcible oil which appeared to poſſeſs all the properties of ſpermaceti. Each of the three alkalis converted it into ſoap, and in a word it exhibited all the properties of the fatty matter of the burial-ground of the Innocens expoſed for ſeveral months to the air. Here then was a glandular organ, which in the midſt of the atmoſphere had undergone a change ſimilar to that of the bodies in the burying-place; and this fact ſufficiently ſhews that an animal ſubſtance which is very far from being of the nature of greaſe may be totally converted into this fatty ſubſtance.

Among the modifications of this remarkable ſubſtance in the burying-ground before mentioned, it was obſerved that the dry, friable, and brittle matter was moſt commonly found near the ſurface of the earth, and the ſoft ductile matter at a greater depth. M. Fourcroy remarks, that this dry matter did not differ from the other merely in containing leſs water, but likewiſe by the volatilization of one of its principles. He promiſes to explain this difference in another memoir, which, if publiſhed, I have not ſeen.

The grave diggers aſſert that near three years are required to convert a body into this fatty ſubſtance. But Mr. Gibbes, in the Philoſophical Tranſactions for 1794, found that lean beef ſecured in a running ſtream was converted into this fatty matter at the end of a month. He judges from facts, that running water is moſt favourable to this proceſs. He took three lean pieces of mutton, and poured on each a quantity of the three ancient mineral acids. At the end of three days, each was much changed: that in the nitrous acid was very ſoft, and converted into the fatty matter; that in the marine acid was not in that time ſo much altered; the vitriolic acid had turned the other black. M. Lavoiſier, in his Elements of Chemiſtry, thinks that this proceſs may hereafter prove of great uſe in ſociety. It is not eaſy to point out what animal ſubſtance, or what ſituation, might be the beſt adapted for an undertaking of this kind. M. L. points out fecal matters; but I have not heard of any converſion having taken place in theſe animal remains, ſimilar to that of the foregoing.

The reſult of M. Fourcroy's enquiries into the ordinary changes of bodies recently depoſited in the earth was not very extenſive. The grave-diggers informed him, that theſe bodies interred do not perceptibly change colour for the firſt ſeven or eight days; that the putrid proceſs diſengages elaſtic fluid which inflates the abdomen, and at length burſts it; that this event inſtantly cauſes vertigo, faintneſs, and nauſea in ſuch perſons as unfortunately are within a certain diſtance of the ſcene where it takes place; but that when the object of

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its action is nearer, a ſudden privation of ſenſe, and frequently death is the conſequence. Theſe men are taught by experience, that no immediate danger is to be feared from the diſguſting buſineſs they are engaged in, excepting at this period, which they regard with the utmoſt terror. They reſiſted every inducement and perſuaſion which theſe philoſophers made uſe of to prevail on them to aſſiſt their reſearches into the nature of this active and pernicious vapour. M. Fourcroy takes occaſion from theſe facts, as well as from the pallid and unwholſome appearance of the grave-diggers, to reprobate burials in great towns or their vicinity.

Such bodies as are interred alone in the midſt of a great quantity of humid earth, are totally deſtroyed by paſſing through the ſucceſſive degrees of the ordinary putrefaction; and this deſtruction is more ſpeedy, the warmer the temperature. But if theſe inſulated bodies be dry and emaciated; if the place of depoſition be likewiſe dry, and the locality and other circumſtances ſuch, that the earth, ſo far from receiving moiſture from the atmoſphere, becomes ſtill more effectually parched by the ſolar rays;—the animal juices are volatilized and abſorbed, the ſolids contract and harden, and a peculiar ſpecies of mummy is produced. But every circumſtance is very different in the common burying-grounds. Heaped together almoſt in contact, the influence of external bodies affects them ſcarcely at all, and they become abandoned to a peculiar diſorganization which deſtroys their texture, and produces the new and moſt permanent ſtate of combination here deſcribed. From various obſervations which I do not here abridge, it was found that this fatty matter was capable of enduring in theſe burying-places for thirty or forty years, and is at length corroded and carried off by the aqueous putrid humidity which there abounds.

SPIKENARD. Nardus Indica, quæ ſpica, ſpica nardi et ſpica Indica officinarum C. B. Andropegon nardus Lin. Indian nard brought from the Eaſt Indies.

It conſiſts of a number of ſlender brittle filaments, ſuppoſed by ſome to be the root, by others the pedicle of the leaves of a plant of the graſs or ruſh kind; but which are properly the head of a root, for Pomet mentions and figures a ſpecimen which had great part of the root itſelf adhering.

Spikenard has a very ſtrong, not agreeable ſmell and taſte, ſcarce to be concealed or overpowered by a large admixture of other ſubſtances. It contains only a ſmall proportion of eſſential oil: on diſtilling an ounce, there was only an appearance of ſome oily particles on the ſurface of the water. Rectified ſpirit brings over nothing: the ſpirituous extract poſſeſſes both the ſmell and taſte of the ſpikenard in a much greater degree than the watery. An ounce yielded a dram of ſpirituous, and afterwards forty-ſix grains of watery extract. Water applied at firſt extracted from the ſame quantity four ſcruples, and ſpirit afterwards twenty-five grains: the indiſſoluble reſiduum weighed in both caſes ſix drams ten grains. Neumann.

SPIRIT. This name was formerly given by chemiſts to all volatile ſubſtances collected by diſtillation. Three principal kinds were diſtinguiſhed; namely, inflammable or ardent ſpirits, acid ſpirits, and alkaline ſpirits. In the firſt claſs were included, not only the product known by the common name of ſpirit of wine, but alſo the light volatile oils, ethers, and the aromatic principle. The contents of the latter claſſes need no enumeration.

The word ſpirit is now almoſt excluſively confined to alcohol, ardent ſpirit, or ſpirit of wine; and the other ſubſtances formerly arranged under the claſſes here mentioned, are diſtinguiſhed by their reſpective peculiar names, without reference to any general arrangement grounded on a property of ſo indiſtinct a nature as that of their being ſeparated from other compounds by diſtillation.

SPIRIT, ARDENT. In order to obtain ardent ſpirit, nothing more is neceſſary than to expoſe wine, beer, or any other fermented vinous liquid, to diſtillation; and the product which comes over is the ardent ſpirit itſelf, contaminated with eſſential oil. If this be rectified by a ſecond diſtillation, it becomes much purer. The moſt volatile part riſes firſt, and is of a leſs ſpecific gravity than that which comes over afterwards.

The reſidue, after the diſtillation of ardent ſpirit from wine, is of a deep colour, a rough acid taſte, and depoſits cryſtals of tartar. The colouring matter is ſoluble in ardent ſpirit. So that it appears, from this imperfect analyſis, that wine conſiſts of water, ardent ſpirit, colouring matter of a reſinous nature, ſugar, tartar, and tartareous acid, and an aromatic principle.

The ſtrength or purity of ardent ſpirit is aſcertained from its ſpecific gravity; for the addition of water renders it heavier. According to M. Bories, whoſe Memoir, publiſhed at Montpellier in the year 1774, obtained the prize propoſed by the ſtates of Languedoc in 1772, the ſpecific gravity of rectified ardent ſpirit, repeatedly poured on dry ſalt of tartar till it would no longer diſſolve or liquefy it, was found by many experiments to be as follows:

Reaumur's Therm. $+ 10^\circ = 820\frac{2900}{5055}$
$15^\circ = 817\frac{65}{5055}$
$20^\circ = 813\frac{2284}{5055}$

The ſpecific gravities of mixtures, by meaſure, of the foregoing ſpirit with diſtilled water, were as follows:

Temperature $+ 15^\circ$ Reaumur.

Spirit		Water		Specific gravity	
	10		0		$817\frac{65}{5055}$
	9	——	1	—— ——	$844\frac{3580}{5055}$
	8	——	2	—— ——	$869\frac{4705}{5055}$
	7	——	3	—— ——	$893\frac{1895}{5055}$
	6	——	4	—— ——	$915\frac{925}{5055}$
	5	——	5	—— ——	$934\frac{3630}{5055}$
	4	——	6	—— ——	$951\frac{3695}{5055}$
	3	——	7	—— ——	$965\frac{1925}{5055}$
	2	——	8	—— ——	$976\frac{1320}{5055}$
	1	——	9	—— ——	$987\frac{715}{5055}$
	0	——	10	—— ——	1,000

Upon the above experiments, which are among the moſt accurate we poſſeſs, it may be obſerved, that the firſt term, or pure ſpirit, ought to be obtained with an alkali perfectly mild, or ſaturated with fixed air; becauſe, otherwiſe, ſolution and combination of the alkali with the ſpirit might take place. By diſtillation of twenty meaſures of the beſt ardent ſpirit of the ſhops, whoſe ſpecific gravity was 0.836 over a lamp in glaſs veſſels, I found the firſt meaſure which came over had a ſpecific gravity of 820, at the temperature of 71° Fahrenheit; which anſwers to $17\frac{1}{3}$ of Reaumur. This is the ſtrongeſt ſpirit mere diſtillation can afford. When ſtrong ardent ſpirit is added to water, a conſiderable heat is produced, a few bubbles of air are emitted, the mixture contracts in its dimenſions,

menſions, and acquires a greater ſpecific gravity than would have been deduced by computation.

It is by no means an eaſy undertaking to determine the ſtrength or relative value of ardent ſpirit, even with ſufficient accuracy for commercial purpoſes. The following requiſites muſt be obtained before this can be well done: The ſpecific gravity of a certain number of mixtures of ardent ſpirit and water muſt be taken ſo near each other, as that the intermediate ſpecific gravities may not perceptibly differ from thoſe deduced from the ſuppoſition of a mere mixture of the fluids: the expanſions or variations of ſpecific gravity in theſe mixtures, muſt be determined at different temperatures: ſome eaſy method muſt be contrived of determining the preſence and quantity of ſaccharine or oleaginous matter which the ſpirit may hold in ſolution, and the effect of ſuch ſolution on the ſpecific gravity: and laſtly, the ſpecific gravity of the fluid muſt be aſcertained by a proper floating inſtrument with a graduated ſtem, or ſet of weights; or, which may be more convenient, with both.

The ſtrength of brandies in commerce is judged by the phial, or by burning. The phial proof conſiſts in agitating the ſpirit in a bottle, and obſerving the form and magnitude of the bubbles, which are larger the ſtronger the ſpirit. Theſe probably depend on the ſolution of reſinous matter from the caſk, which is taken up in greater quantities, the ſtronger the ſpirit. It is not difficult however to produce this appearance by various ſimple additions to weak ſpirit. The proof by burning is alſo fallacious; becauſe the magnitnde of the flame, and quantity of reſidue, in the ſame ſpirit, vary greatly with the form of the veſſel it is burned in. If the veſſel be kept cool, or ſuffered to become hot, if it be deeper or ſhallower, the reſults will not be the ſame in each caſe. It does not follow, however, but that manufacturers and others may in many inſtances receive conſiderable information from theſe ſigns, in circumſtances exactly alike, and in the courſe of operations wherein it would be inconvenient to recur continually to experiments of ſpecific gravity.

The importance of this object, as well for the purpoſes of revenue as of commerce, induced the Britiſh government to employ Dr. Blagden to inſtitute a very minute and accurate ſeries of experiments. Theſe may be conſidered as fundamental reſults; for which reaſon, I ſhall inſert the whole in this place, from the Philoſophical Tranſactions for 1790, in the words of the author.

The firſt object to which the experiments were directed, was to aſcertain the quantity and law reſulting from the mutual penetration of water and ſpirit.

All bodies in general expand by heat; but the quantity of this expanſion, as well as the law of its progreſſion, is probably not the ſame in any two ſubſtances. In water and ſpirit they are remarkably different. The whole expanſion of pure ſpirit from 30° to 100° of Fahrenheit's thermometer, is not leſs than $\frac{1}{25}$ of its whole bulk at 30°; whereas that of water, in the ſame interval, is only $\frac{1}{145}$ of its bulk. The laws of their expanſion are ſtill more different than the quantities. If the expanſion of quickſilver be, as uſual, taken for the ſtandard (our thermometers being conſtructed with that fluid), the expanſion of ſpirit is, indeed, progreſſively increaſing with reſpect to that ſtandard, but not much ſo within the above-mentioned interval; whilſt water kept from freezing to 30°, which may eaſily be done, will abſolutely contract as it is heated for ten or more degrees, that is, to 40° or 42° of the thermometer, and will then begin to expand as its heat is augmented, at firſt ſlowly, and afterwards gradually more rapidly, ſo as to obſerve upon the whole a very increaſing progreſſion. Now, mixtures of theſe two ſubſtances will, as may be ſuppoſed, approach to the leſs or the greater of theſe progreſſions, according as they are compounded of more ſpirit or more water, whilſt their total expanſion will be greater, according as more ſpirit enters into their compoſition; but the exact quantity of the expanſion, as well as law of the progreſſion, in all of them, can be determined only by trials. Theſe were, therefore, the two other principal objects to be aſcertained by experiment.

The firſt ſtep towards a right performance of the experiments was to procure the two ſubſtances with which they were to be made as pure as poſſible. Diſtilled water is in all caſes ſo nearly alike, that no difficulty occurred with regard to it; but the ſpecific gravity of pure ſpirit, or alcohol, has been given ſo very differently by the authors who have treated of it; that a particular ſet of experiments appeared neceſſary for determining to what degree of ſtrength rectified ſpirits could conveniently be brought. The perſon engaged to make theſe experiments was Dr. Dollfuſs, an ingenious Swiſs gentleman then in London, who had diſtinguiſhed himſelf by ſeveral publications on chemical ſubjects. Dr. Dollfuſs, having been furniſhed by government with ſpirit for the purpoſe, rectified it by repeated and ſlow diſtillations till its ſpecific gravity became ſtationary in this manner of operating: he then added dry cauſtic alkali to it, let it ſtand for a few days, poured off the liquor, and diſtilled it with a ſmall addition of burnt alum, placing the receiver in ice. By this method he obtained a ſpirit whoſe ſpecific gravity was ,8188 at 60° of heat. Perceiving however that he could not conveniently get the quantity of ſpirit he wanted lighter than ,82527 at 60°, he fixed upon that ſtrength as a ſtandard, to which he found the above-mentioned lighter ſpirit could be reduced by adding to it a $\frac{27}{10000}$ part of water; and with this ſpirit and diſtilled water he made a ſeries of experiments for determining the ſpecific gravity of different mixtures of theſe fluids in different degrees of heat.

The proceſs followed by Dr. Dollfuſs is not here given as the beſt poſſible for obtaining pure ſpirit; nor was the reſult of it in fact the lighteſt alcohol that has been procured. Some ſpirit has been tried ſince that time, whoſe ſpecific gravity was ,813 at 60°. This was furniſhed by Dr. George Fordyce, F. R. S. who ſucceeded in bringing it to that ſtrength chiefly by adding the alkali very hot. Care muſt be taken that none of the cauſtic alkali comes over in the diſtillation. Some alcohol was alſo ſent for trial, by Mr. Lewis an eminent diſtiller in Holborn, whoſe ſpecific gravity at the ſame temperature was ,814.

It was with ſpirit rectified from malt ſpirits that Dr. Dollfuſs's ſeries of experiments was made; but he tried ſeveral comparative experiments, with ſuch as had been rectified from rum and brandy, and found no other difference than what might fairly be aſcribed to unavoidable errors.

Theſe experiments of Dr. Dollfuſs were repeated by Mr. Gilpin, clerk of the Royal Society; and as the deductions in this account will be taken chiefly from that laſt ſet of experiments, it is proper here to deſcribe minutely the method obſerved by Mr. Gilpin in his operation. This naturally reſolves itſelf into two parts: the way of making the mixtures, and the way of aſcertaining their ſpecific gravity.

1. The mixtures were made by weight, as the only accurate method of fixing the proportions. In fluids of ſuch very unequal expanſions by heat as water and alcohol, if meaſures had been employed, increaſing or decreaſing in regular

proportions to each other, the proportions of the maſſes would have been ſenſibly irregular; now the latter was the object in view, namely, to determine the real quantity of ſpirit in any given mixture, abſtracting the conſideration of its temperature. Beſides, if the proportions had been taken by meaſure, a different mixture ſhould have been made at every different degree of heat. But the principal conſideration was, that with a very nice balance, ſuch as was employed on this occaſion, quantities can be determined to much greater exactneſs by weight than by any practicable way of meaſurement. The proportions were therefore always taken by weight. A phial being provided of ſuch a ſize as that it ſhould be nearly full with the mixture, was made perfectly clean and dry, and being counterpoiſed, as much of the pure ſpirit as appeared neceſſary was poured into it. The weight of this ſpirit was then aſcertained, and the weight of diſtilled water required to make a mixture of the intended proportions was calculated. This quantity of water was then added, with all the neceſſary care, the laſt portions being put in by means of a well-known inſtrument, which is compoſed of a ſmall diſh terminating in a tube drawn to a fine point: the top of the diſh being covered with the thumb, the liquor in it is prevented from running out through the tube by the preſſure of the atmoſphere, but inſtantly begins to iſſue by drops, or a very ſmall ſtream, upon raiſing the thumb. Water being thus introduced into the phial, till it exactly counterpoiſed the weight, which having been previouſly computed, was put into the oppoſite ſcale, the phial was ſhaken, and then well ſtopped with its glaſs ſtopple, over which leather was tied very tight, to prevent evaporation. No mixture was uſed till it had remained in the phial at leaſt a month, for the full penetration to have taken place; and it was always well ſhaken before it was poured out to have its ſpecific gravity tried.

2. There are two common methods of taking the ſpecific gravity of fluids; one, by finding the weight which a ſolid body loſes by being immerſed in them; the other, by filling a convenient veſſel with them, and aſcertaining the increaſe of weight it acquires. In both caſes a ſtandard muſt have been previouſly taken, which is uſually diſtilled water; namely, in the firſt method by finding the weight loſt by the ſolid body in the water, and in the ſecond method, the weight of the veſſel filled with water. The latter was preferred for the following reaſons:

When a ball of glaſs, which is the propereſt kind of ſolid body, is weighed in any ſpirituous or watery fluid, the adheſion of the fluid occaſions ſome inaccuracy, and renders the balance comparatively ſluggiſh. To what degree this effect proceeds is uncertain; but from ſome experiments made by Mr. Gilpin, with that view, it appears to be very ſenſible. Moreover, in this method a large ſurface muſt be expoſed to the air during the operation of weighing, which, eſpecially in the higher temperatures, would give occaſion to ſuch an evaporation as to alter eſſentially the ſtrength of the mixture. It ſeemed alſo as if the temperature of the fluid under trial could be determined more exactly in the method of filling a veſſel, than in the other: for the fluid cannot well be ſtirred while the ball to be weighed remains immerſed in it; and as ſome time muſt neceſſarily be ſpent in the weighing, the change of heat which takes place during that period will be unequal through the maſs, and may occaſion a ſenſible error. It is true, on the other hand, that, in the method of filling a veſſel, the temperature could not be aſcertained with the utmoſt preciſion, becauſe the neck of the veſſel employed, containing about ten grains, was filled up to the mark with ſpirit not exactly of the ſame temperature, as will be explained preſently: but this error, it is ſuppoſed, would by no means equal the other, and the utmoſt quantity of it may be eſtimated very nearly. Finally, it was much eaſier to bring the fluid to any given temperature when it was in a veſſel to be weighed, than when it was to have a ſolid body weighed in it; becauſe in the former caſe the quantity was ſmaller, and the veſſel containing it more manageable, being readily heated with the hand or warm water, and cooled with cold water: and the very circumſtance, that ſo much of the fluid was not required, proved a material convenience. The particular diſadvantage in the method of weighing in a veſſel, is the difficulty of filling it with extreme accuracy; but when the veſſel is judiciouſly and neatly marked, the error of filling will, with due care, be exceedingly minute. By ſeveral repetitions of the ſame experiments, Mr. Gilpin ſeemed to bring it within the $\frac{1}{15000}$th part of the whole weight.

The above-mentioned conſiderations induced Dr. Blagden, as well as the gentlemen employed in the experiments, to give the preference to weighing the fluid itſelf; and that was accordingly the method practiſed both by Dr. Dollfuſs and Mr. Gilpin in their operations.

The veſſel choſen as moſt convenient for the purpoſe was a hollow glaſs ball, terminating in a neck of ſmall bore. That which Dr. Dollfuſs uſed held 5800 grains of diſtilled water; but as the balance was ſo extremely accurate, it was thought expedient, upon Mr. Gilpin's repetition of the experiments, to uſe one of only 2965 grains capacity, as admitting the heat of any fluid contained in it to be more nicely determined. The ball of this veſſel, which may be called the weighing-bottle, meaſured about 2.8 inches in diameter, and was ſpherical, except a ſlight flattening on the part oppoſite to the neck, which ſerved as a bottom for it to ſtand upon. Its neck was formed of a portion of a barometer tube, ,25 of an inch in bore, and about $1\frac{1}{2}$ inch long; it was perfectly cylindrical, and on its outſide, very near the middle of its length, a fine circle or ring was cut round it with a diamond, as the mark to which it was to be filled with the liquor. This mark was made by fixing the bottle in a lathe, and turning it round with great care, in contact with the diamond. The glaſs of this bottle was not very thick; it weighed 916 grains, and with its ſilver cap 936.

When the ſpecific gravity of any liquor was to be taken by means of this bottle, the liquor was firſt brought nearly to the required temperature, and then the bottle was filled with it up to the beginning of the neck only, that there might be room for ſhaking it. A very fine and ſenſible thermometer was then paſſed through the neck of the bottle into the contained liquor, which ſhewed whether it was above or below the intended temperature. In the former caſe the bottle was brought into colder air, or even plunged for a moment into cold water; the thermometer in the mean time being frequently put into the contained liquor, till it was found to ſink to the right point. In like manner, when the liquor was too cold, the bottle was brought into warmer air, immerſed in warm water, or more commonly held between the hands, till upon repeated trials with the thermometer the juſt temperature was found. It will be underſtood, that during the courſe of this heating or cooling, the bottle was very frequently ſhaken between each immerſion of the thermometer; and the top of the neck was kept covered, either with the finger, or a ſilver cap made on purpoſe, as conſtantly as poſſible. Hot water was uſed to raiſe the temperature only in heats of 80° and upwards, inferior heats being obtained by applying the hands to the bottle: when the hot water was employed, the ball of the bottle was plunged into it, and again quickly lifted out, with the neceſſary ſhaking interpoſed, as often as was neceſſary for communicating the required heat to the liquor; but care was taken to wipe the bottle dry after each immerſion, before it was ſhaken, leſt any adhering moiſture might by accident get into it. The liquor having by theſe means been brought to the deſired temperature; the next operation was to fill up the bottle exactly to the mark upon the neck, which was done with ſome of the ſame liquor, by means of a glaſs funnel with a very ſmall bore. Mr. Gilpin endeavoured to get that portion of the liquor which was employed for this purpoſe, pretty nearly to the temperature of the liquor contained in the bottle; but as the whole quantity to be added never exceeded ten grains, a difference of ten degrees in the heat of that ſmall quantity, which is more than it ever amounted to, would have occaſioned an error of only $\frac{1}{30}$ of a degree in the temperature of the maſs. Enough of the liquor was put in to fill the neck rather above the mark, and the ſuperfluous quantity was then abſorbed to great nicety, by bringing into contact with it the fine point of a ſmall roll of blotting paper. As the ſurface of the liquor in the neck would be always concave, the bottom or centre of this concavity was the part made to coincide with the mark round the glaſs; and in viewing it care was taken, that the near and oppoſite ſides of the mark ſhould appear exactly in the ſame line, by which means all parallax was avoided. A ſilver cap, which fitted tight, was then put upon the neck, to prevent evaporation; and the whole apparatus was in that ſtate laid in the ſcale of the balance, to be weighed with all the exactneſs poſſible.

The ſpirit employed by Mr. Gilpin was furniſhed to him by Dr. Dollfuſs, under whoſe inſpection it had been rectified from rum ſupplied by government. Its ſpecific gravity, at 60 degrees of heat, was ,82514. It was firſt weighed pure, in the abovementioned bottle, at every five degrees of heat, from 30 to 100 incluſively. Then mixtures were formed of it, and diſtilled water, in every proportion, from $\frac{1}{20}$th of the water to equal parts of water and ſpirit; the quantity of water added being ſucceſſively augmented, in the proportion of five grains to one hundred of the ſpirit; and theſe mixtures were alſo weighed in the bottle, like the pure ſpirit, at every five degrees of heat. The numbers hence reſulting are delivered in the following table; where the firſt column ſhews the degrees of heat; the ſecond gives the weight of the pure ſpirit contained in the bottle at thoſe different degrees; the third gives the weight of a mixture in the proportions of 100 parts by weight of that ſpirit to 5 of water, and ſo on ſucceſſively till the water and the ſpirit are in equal parts. The bottle itſelf, with its cap, having been previouſly counterpoiſed, theſe numbers are the weights of the liquor contained in it, in grains and hundredths of a grain. They are the mean of three ſeveral experiments at leaſt, as Mr. Gilpin always filled and weighed the bottle over again that number of times, if not oftener. The heat was taken at the even degree, as ſhewn by the thermometer, without any allowance in the firſt inſtance, becauſe the coincidence of the mercury with a diviſion, can be perceived more accurately than any fraction can be eſtimated; and the errors of the thermometers, if any, it was ſuppoſed would be leſs upon the grand diviſions of 5 degrees, than in any others. It muſt be obſerved, that Mr. Gilpin uſed the ſame mixture throughout all the different temperatures, heating it up from 30° to 100°; hence ſome ſmall error in its ſtrength may have been occaſioned in the higher degrees, by more ſpirit evaporating than water;

but this, it is believed, muſt have been trifling, and greater inconvenience would probably have reſulted from interpoſing a freſh mixture.

Here follows in the report, a table of the weights in grains at the different degrees of temperature. Theſe weights being elements from which ſpecific gravities are computed, I have not thought it neceſſary to inſert it here, more eſpecially as the computation of the ſpecific gravities appears to have been carefully reviſed and corrected by Mr. Gilpin, previous to the inſertion of his large table in the Tranſactions for 1794.

In order to deduce the ſpecific gravities from the numbers in the preceding table, it was neceſſary to weigh diſtilled water in the ſame veſſel. This Mr. Gilpin did, in the ſame manner as before, at the different degrees of heat; and the reſult of his experiments is delivered in the following table, where the firſt column ſhews the heat, and the ſecond gives the weight of the water, at that temperature, contained in the bottle.

Weights and Specific Gravities of Diſtilled Water.

Heat.	Weight of the Water.	Specific Gravity of the Water.	Specific Gravity as by the Table in Ph. Tr. 1794.
30°	Grains.		1,00074
35	2967,03	1,00087	1,00090
40	2967,34	1,00091	1,00094
45	2967,29	1,00084	1,00086
50	2966,97	1,00066	1,00068
55	2966,39	1,00040	1,00038
60	2965,39	1,00000	1,00000
65	2964,17	,99952	,99950
70	2962,72	,99896	,99894
75	2961,03	,99832	,99830
80	2959,13	,99762	,99759
85	2957,03	,99685	
90	2954,80	,99602	
95	2952,20	,99507	
100	2949,36	,99404	

The numbers in the additional column are taken from Mr. Gilpin's table in the Tranſactions for 1794, and are no doubt the moſt accurate.

There would be two methods for computing the ſpecific gravity at the different temperatures from theſe numbers; one, by taking the weight of the water, at the particular temperature in queſtion, for the ſtandard; and the other by fixing on one certain temperature of the water, for inſtance 60°, to be the ſtandard, with its bulk, at which that of the ſpirit at all different degrees ſhall be compared. Dr. Blagden preferred the latter method, though not the moſt uſual, becauſe it ſhews, more readily and ſimply, the progreſſion obſerved in the changes of ſpecific gravity, according to the heat and ſtrength of the mixture. This method, however, rendered it neceſſary to make an allowance for the contraction and expanſion of the bottle uſed for weighing the liquors, according to the deviation of their temperature from 60°, either below or above. To obtain this correction, the expanſion of hollow glaſs was taken from General Roy's experiments in the lxxvth volume of the Philoſophical Tranſactions, as ,0000517 of an inch upon a foot for every degree of heat; whence its effect, in enlarging the capacity of a ſphere, was computed, and the reſulting correction added to the weight of the liquors in heats below 60°, and ſubtracted from it in heats above. On the ſame account a third column is given, in the preceding table, to ſhew the ſpecific gravity of water at the different temperatures, its weight at 60° being taken as the ſtandard.

Another correction alſo became neceſſary, on account of the part of the ſtem of the thermometer which was not immerſed in the liquor. This inſtrument, made by Ramſden, had its ball ,22 of an inch in diameter, and its ſtem 13 inches in length. From the ball to the commencement of the ſcale 3,6 inches of the ſtem were bare, and then the ſcale began, which reached from 15 to 110 degrees. The part of it particularly made uſe of in theſe experiments, namely from 30° to 100°, meaſured 6,82 inches. The ſcale was made of ivory, and carried diviſions to every fifth of a degree, the quarters of which could be readily eſtimated; ſo that the inſtrument could be read off to twentieths of degrees. When the thermometer was immerſed in the weighing bottle, the liquor reached up nearly to what would have been 0° upon its ſtem; hence, as the heat of the room in which the experiments were made remained about 60°, the correction for the different heat of the quickſilver in the ſtem from that in the ball of the thermometer was calculated according to Mr. Cavendiſh's table, given in the lxxvth volume of the Philoſophical Tranſactions. Thus the real heat of the fluid in the weighing-bottle being found, an allowance was made to reduce it to the exact degree indicated on the ſcale of the thermometer.

The preciſe ſpecific gravity of the pure ſpirit employed was ,82514; but to avoid an inconvenient fraction, it is taken, in conſtructing the table of ſpecific gravities, as ,825 only, a proportional deduction being made from all the other numbers. Thus the following table gives the true ſpecific gravity, at the different degrees of heat, of a pure rectified ſpirit, whoſe ſpecific gravity at 60° is ,825, together with the ſpecific gravities of different mixtures of it with water, at thoſe different temperatures.

I have not copied the table from the report, excepting only the numbers anſwering to the temperatures 95 and 100. For I perceive that it differs in the two laſt decimal figures from the table publiſhed by Mr. Gilpin in the Tranſactions for 1794, to which reference has already been made. I ſuppoſe the two higher temperatures may have been omitted in that table as leſs uſeful, and perhaps leſs accurate. The following table is extracted from the laſt table of Mr. Gilpin. I ſhould have willingly inſerted the whole, in which the mixtures differ from each other by unity only, and are exhibited in meaſure as well as in weight, if the limits of the preſent work could have allowed it to be done. Mr. Gilpin's table likewiſe ſhews the bulk of the mixture, the diminution of bulk, the quantity of ſpirit per cent. and a decimal multiplier, which being applied to the bulk of the mixture, gives the meaſure of pure ſpirit in a mixture of that denſity.

Real Specific Gravities at the different Temperatures.

Heat.	The pure ſpirit.	100 grains of ſpirit to 5 grains of water.	100 grains of ſpirit to 10 grains of water.	100 grains of ſpirit to 15 grains of water.	100 grains of ſpirit to 20 grains of water.	100 grains of ſpirit to 25 grains of water.	100 grains of ſpirit to 30 grains of water.	100 grains of ſpirit to 35 grains of water.	100 grains of ſpirit to 40 grains of water.	100 grains of ſpirit to 45 grains of water.	100 grains of ſpirit to 50 grains of water.
30°	,83896	,84995	,85957	,86825	,87585	,88282	,88921	,89511	,90054	,90558	,91023
35	83672	84769	85729	86587	87357	88059	88701	89294	89839	90345	90811
40	83445	84539	85507	86361	87134	87838	88481	89073	89617	90127	90596
45	83214	84310	85277	86131	86905	87613	88255	88849	89396	89909	90380
50	82977	84076	85042	85902	86676	87384	88030	88626	89174	89684	90160
55	82736	83834	84802	85664	86441	87150	87796	88393	88945	89458	89933
60	82500	83599	84568	85430	86208	86918	87569	88169	88720	89232	89707
65	82262	83362	84334	85193	85976	86686	87337	87938	88490	89006	89479
70	82023	83124	84092	84951	85736	86451	87105	87705	88254	88773	89252
75	81780	82878	83851	84710	85496	86212	86864	87466	88018	88538	89018
80	81530	82631	83603	84467	85248	85966	86622	87228	87776	88301	88781
85	81291	82396	83371	84243	85036	85757	86411	87021	87590	88120	88605
90	81044	82150	83126	84001	84797	85518	86172	86787	87360	87889	88376
95	80794	81900	82877	83753	84550	85272	85928	86542	87114	87654	88146
100	80548	81657	82639	83513	84308	85031	85688	86302	86879	87421	87915

Heat.	100 grains of ſpirit to 55 grains of water.	100 grains of ſpirit to 60 grains of water.	100 grains of ſpirit to 65 grains of water.	100 grains of ſpirit to 70 grains of water.	100 grains of ſpirit to 75 grains of water.	100 grains of ſpirit to 80 grains of water.	100 grains of ſpirit to 85 grains of water.	100 grains of ſpirit to 90 grains of water.	100 grains of ſpirit to 95 grains of water.	100 grains of ſpirit to 100 grains of water.
30°	,91449	,91847	,92217	,92563	,92889	,93191	,93474	,93741	,93991	,94222
35	91241	91640	92009	92355	92680	92986	93274	93541	93790	94025
40	91026	91428	91799	92151	92476	92783	93072	93341	93592	93827
45	90812	91211	91584	91937	92264	92570	92859	93131	93382	93621
50	90596	90997	91370	91723	92051	92358	92647	92919	93177	93419
55	90367	90768	91144	91502	91837	92145	92436	92707	92963	93208
60	90144	90549	90927	91287	91622	91933	92225	92499	92758	93002
65	89920	90328	90707	91066	91400	91715	92010	92283	92546	92794
70	89695	90104	90484	90847	91181	91493	91793	92069	92333	92580
75	89464	89872	90252	90617	90952	91270	91569	91849	92111	92364
80	89225	89639	90021	90385	90723	91046	91340	91622	91891	92142
85	89043	89460	89843	90209	90558	90882	91186	91465	91729	91969
90	88817	89230	89617	89988	90342	90668	90967	91248	91511	91751
95	88588	89003	89390	89763	90119	90443	90747	91029	91290	91531
100	88357	88769	89158	89536	89889	90215	90522	90805	91066	91310

Heat.	95 grains of ſpirit to 100 grains of water.	90 grains of ſpirit to 100 grains of water.	85 grains of ſpirit to 100 grains of water.	80 grains of ſpirit to 100 grains of water.	75 grains of ſpirit to 100 grains of water.	70 grains of ſpirit to 100 grains of water.	65 grains of ſpirit to 100 grains of water.	60 grains of ſpirit to 100 grains of water.	55 grains of ſpirit to 100 grains of water.	50 grains of ſpirit to 100 grains of water.
30°	,94447	,94675	,94920	,95173	,95429	,95681	,95944	,96209	,96470	,96719
35	94249	94484	94734	94988	95246	95502	95772	96048	96315	96579
40	94058	94295	94547	94802	95060	95328	95602	95879	96159	96434
45	93860	94096	94348	94605	94871	95143	95423	95705	95993	96280
50	93658	93897	94149	94414	94683	94958	95243	95534	95831	96126
55	93452	93696	93948	94213	94486	94767	95057	95357	95662	95966
60	93247	93493	93749	94018	94296	94579	94876	95181	95193	95804
65	93040	93285	93546	93822	94099	94388	94689	95000	95318	95635
70	92828	93076	93337	93616	93898	94193	94500	94813	95139	95469
75	92613	92865	93132	93413	93695	93989	94301	94623	94957	95292
80	92393	92646	92917	93201	93488	93785	94102	94431	94768	95111

Heat.	45 grains of ſpirit to 100 grains of water.	40 grains of ſpirit to 100 grains of water.	35 grains of ſpirit to 100 grains of water.	30 grains of ſpirit to 100 grains of water.	25 grains of ſpirit to 100 grains of water.	20 grains of ſpirit to 100 grains of water.	15 grains of ſpirit to 100 grains of water.	10 grains of ſpirit to 100 grains of water.	5 grains of ſpirit to 100 grains of water.
30°	,96967	,97200	,97418	,97635	,97860	,98108	,98412	,98804	,99334
35	96840	97086	97319	97556	97801	98076	98397	98804	99344
40	96706	96967	97220	97472	97737	98033	98373	98795	99345
45	96563	96840	97110	97384	97666	97980	98338	98774	99338
50	96420	96708	96995	97284	97589	97920	98293	98745	99316
55	96272	96575	96877	97181	97500	97847	98239	98702	99284
60	96122	96437	96752	97074	97410	97771	98176	98654	99244
65	95962	96288	96620	96959	97309	97688	98106	98594	99194
70	95802	96143	96484	96836	97203	97596	98028	98527	99134
75	95638	95987	96344	96708	97086	97495	97943	98454	99066
80	95467	95826	96192	96568	96963	97385	97845	98367	98991

From this table, when the ſpecific gravity of any ſpirituous liquor is aſcertained, it will be eaſy to find the quantity of rectified ſpirit of the abovementioned ſtandard, contained in any given quantity of it, either by weight or meaſure. As common arithmetic is competent to furniſh the rules for this purpoſe, it would be ſuperfluous to give them here. Dr. Blagden is of opinion, that all the objects of enquiry ſhould be reduced to tables; the firſt of which might exhibit the ſpecific gravities of different mixtures, from 1 to 100 parts of water, increaſing by one, at every degree of heat from 40 to 80, being the utmoſt limits of temperature that can be wanted in common practice. This table need only be calculated to three places of figures, which will always give the quantity of ſpirit true within a fiftieth part of the whole, and in the moſt uſual degrees of heat within a hundredth; and to this number of figures the aerometer, or hydrometer, ſhewing the ſpecific gravities, could be ſuited. A further reaſon for continuing only to three places of figures is, that, accurate as Mr. Gilpin's experiments have been, ſome irregularities are found in the two laſt of the five decimals to which his tables are calculated. The greateſt of theſe irregularities, Dr. Blagden is of opinion, do not exceed the quantity correſponding to a difference of one-fifth of a degree of heat, and in general they are much leſs. A table might be conſtructed to ſhew what the numbers would probably have been to the five places of decimals, if there had been no kind of error in the experiments. Another table ſhould be of the volumes, exhibiting what proportion the ſpirit and water bore to each other by meaſure or bulk, in the different mixtures; whence might be calculated a very uſeful table of diminutions, to ſhew when a given weight, or volume, of a certain ſpirit and water are mixed together, how much their bulk would be diminiſhed; or what is called by diſtillers the concentration. From ſuch a table the diſtiller could learn what quantity of water he muſt mix with ſpirit of a given ſtrength, in order to reduce it to proof ſpirit, or any other ſtrength; and likewiſe what quantity of proof ſpirit, or ſpirit of any other ſtrength, he may obtain, by adding water to ſpirit of a given ſtrength; both circumſtances very neceſſary to be known in the trade, and which ſome of the ſliding rulers now in uſe profeſs to point out.

Dr. Blagden choſe this point of the thermometer 60° in preference to 55°, becauſe it is much the moſt ſuitable for experiments, being the temperature at which a room feels pleaſant, and in which any operation, however ſlow and tedious, can be executed without the uneaſy ſenſation of cold; for this reaſon it has been adopted by many Engliſh philoſophers. In the table formerly recommended, from 40 to 80 degrees of the thermometer, it will be the middle temperature.

The ſpecific gravity of ,825 having been fixed upon as the ſtandard of rectified ſpirit in the tables, Mr. Gilpin was deſired to aſcertain by experiment what proportion of water would be neceſſary to reduce the lighteſt alcohol in his poſſeſſion to that ſtandard. This was ſome alcohol already mentioned, which Mr. Lewis had furniſhed; and its ſpecific gravity being ,814196 at 60°, 3000 grains of it mixed with 135 grains of diſtilled water formed a compound, whoſe ſpecific gravity was ,825153; that is in round numbers, 100 grains of alcohol at ,814 with 4,5 grains of water form the ſtandard of ſpirit at ,825.

Dr. Blagden obſerves, that the ſmall quantities mixed and weighed ought not to be any objection to the preceding experiments; that if the inſtruments be exceedingly exact, and the experimenters equal to the taſk of uſing them properly, the errors upon moderate quantities will be quite as ſmall in proportion as upon large; and that in this particular inſtance, where the greateſt ſource of error lay in the determination of the heat, the ſmaller quantities had in that reſpect an evident advantage, it being much eaſier to bring ſix ounces of a liquor to an uniform temperature, than ſo many gallons. One of the moſt eſſential inſtruments, namely the balance, was ſo much ſuperior in nicety to any thing that could be wanted in theſe experiments, that error in weighing muſt be thrown entirely out of the queſtion. It was conſtructed by Mr. Ramſden; and ſome account, though very imperfect, of its admirable mechaniſm, as well as of its extreme ſenſibility, even when loaded with conſiderable weights, has been given in the xxxiiid volume of the Journal de Phyſique.

Dr. Blagden concludes this part of the report with obſerving, that as the experiments were made with pure ſpirit and water, if any extraneous ſubſtances are contained in the liquor to be tried, the ſpecific gravity in the tables will not give exactly the proportions of water and ſpirit in it. The ſubſtances likely to be found in ſpirituous liquors, where no fraud is ſuſpected, are eſſential oils; ſometimes empyreumatic, mucilaginous or extractive matter, and perhaps ſome ſaccharine matter. The effect of theſe, in the courſe of trade, ſeems to be hardly ſuch as would be worth the cognizance of the exciſe, nor could it eaſily be reduced to certain rules. Eſſential and empyreumatic oils are nearly of the ſame ſpecific gravity as ſpirit, in general rather lighter, and therefore, notwithſtanding the mutual penetration, will probably make little change in the ſpecific gravity of any ſpirituous liquor in which they are diſſolved. The other ſubſtances are all heavier than ſpirit; the ſpecific gravity of common gum being 1,482, and of ſugar 1,606, according to the tables of M. Briſſon. The effect of them therefore will be to make ſpirituous liquors appear leſs ſtrong than they really are. An idea was once entertained of endeavouring to determine this matter with ſome preciſion; and accordingly Dr. Dollfuſs evaporated 1000 grains of brandy, and the ſame quantity of rum, to dryneſs; the former left a reſiduum of 40 grains, the latter only of 8½ grains. The 40 grains of reſiduum from the brandy, diſſolved again in a mixture of 100 of ſpirit, with 50 of water, increaſed its ſpecific gravity ,00041: hence the effect of this extraneous matter upon the ſpecific gravity of the brandy containing it, would be to increaſe the fifth decimal by 6 nearly, equal to what would indicate in the above-mentioned mixture, about one-ſeventh of a grain of water more than the truth, to 100 of ſpirit; a quantity much too minute for the conſideration of government*.

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* Here ends the Report of Dr. Blagden.

The moſt remarkable characteriſtic property of ardent ſpirit, is its ſolubility or combination in all proportions with water; a property poſſeſſed by no other combuſtible ſubſtance. When it is burned in a chimney which communicates with the worm-pipe of a diſtilling apparatus, the product which is condenſed is found to conſiſt of water, which exceeds the ſpirit in weight about one eighth part. If ardent ſpirit be burned in cloſed veſſels with vital air, the product is found to be water and fixed air. Whence it is inferred that ardent ſpirit conſiſts of inflammable air, united either to fixed air or its acidifiable baſe; and that the vital air, uniting on the one part with the inflammable air, forms water; and on the other with the baſe of the fixed air, forms that acid *.

A conſiderable number of the uſes of this fluid as a menſtruum have paſſed under our obſervation in the various articles of this work. The mutual action between ardent ſpirit and acids produces a light, volatile, and inflammable oil, called ether. See ETHER. Pure alkalis unite with ſpirit of wine, and form alkaline tinctures. Few of the neutral ſalts unite with this fluid, except ſuch as contain the volatile alkali. The mild fixed alkalis, or combinations of alkali and fixed air, are not ſoluble in it. From the ſtrong attraction which exiſts between ardent ſpirit and water, it unites with this laſt in ſaline ſolutions, and in moſt caſes precipitates the ſalt. This is a pleaſing experiment, which never fails to ſurpriſe thoſe who are unacquainted with chemical effects. If, for example, a ſaturated ſolution of nitre in water be taken, and an equal quantity of ſtrong ſpirit of wine be poured upon it, the mixture will conſtitute a weaker ſpirit, which is incapable of holding the nitre in ſolution; it therefore falls to the bottom inſtantly, in the form of minute cryſtals.

The degrees of ſolubility of many neutral ſalts in ſpirit of wine, are exactly aſcertained by experiments made by Macquer, of which an account is publiſhed in the Memoirs of the Turin Academy. The ſpirit of wine he employed was carefully freed from ſuperabundant phlegm by repeated rectifications, without addition of any intermediate ſubſtance. A phial which contained one Paris ounce of diſtilled water when Reaumur's thermometer was at ſix degrees above the freezing point, contained of this rectified ſpirit ſix gros and fifty-four grains. The ſalts employed in his experiments were previouſly deprived of their water of cryſtallization by a careful drying. He poured into a matraſs, upon each of the ſalts thus prepared, half an ounce of his ſpirit of wine, and ſet the matraſs in a ſand-bath. When the ſpirit began to boil, he filtrated it while it was hot, and left it to cool that he might obſerve the cryſtallizations which took place. He then evaporated the ſpirit, and weighed the ſaline reſiduums. He repeated theſe experiments a ſecond time, with this difference, that inſtead of evaporating the ſpirit in which the ſalt had been digeſted, he ſet fire to it in order to examine the phenomena which its flame might exhibit. The principal reſults of his experiments are ſubjoined.

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* For an account of theſe experiments, and the precautions neceſſary to be attended to in making them, conſult the Memoirs of M. Lavoiſier, in the Memoirs of the Royal Academy at Paris for 1781 and 1784.

Quantity of grains.	Salts ſoluble in 200 grains of ſpirit.	Peculiar phenomena of the flame.
0	Vitriolated tartar	None
4	Nitre	Flame larger, higher, more ardent, yellow, and luminous
5	Salt of Sylvius	Large, ardent, yellow, and luminous
0	Glauber's ſalt	Conſiderably red
15	Cubic nitre	Yellow, luminous, detonating
0	Common ſalt	Larger, more ardent, and reddiſh
0	Vitriolic ammoniac	None
108	Nitrous ammoniac	Whiter, more luminous
24	Sal ammoniac	None
0	Selenites	None
288	Nitre with calcareous baſis	Larger, more luminous, red and decrepitating
288	Marine ſalt with calcareous baſis	Like that of the calcareous nitre
0	Vitriol of ſilver	None
84	Nitre of ſilver	None
0	Luna cornea	None
0	Vitriol of mercury	None
0	Nitre of mercury	None
204	Corroſive ſublimate	Large, yellow, luminous and decrepitating
0	Martial vitriol	None
4 *	Martial nitre	Red and decrepitating
36	Martial marine ſalt	More white, luminous and ſparkling
0	Vitriol of copper	None
48	Cupreous nitre	More white, luminous, and green, much ſmoke. The ſaline reſiduum became black and burnt
48	Cupreous marine ſalt	Fine green, white, and red fulgurations.

Macquer accompanies the relation of his experiments with many judicious reflections, not eaſily capable of abridgment.

Sulphur does not appear to be acted upon more ſtrongly by ardent ſpirit than by water. If ſulphur in ſublimation meet with the vapour of ſpirit of wine, a very ſmall portion combines with it, which communicates an hepatic odour to the fluid. The increaſed ſurface of the two ſubſtances appears to favour the combination.

Phoſphorus is ſparingly ſoluble in ardent ſpirit, but in greater quantity by heat than in cold. The addition of water to this ſolution affords an opake milky fluid, which gradually becomes clear by the ſubſidence of the phoſphorus.

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* Theſe four grains were an acid matter. This ſalt could not be dried without decompoſition.

Earths ſeem to have ſcarce any action upon ardent ſpirit. Quick-lime, however, produces ſome alteration in this fluid, by changing its flavour and rendering it of a yellow colour. A ſmall portion is probably taken up.

Soaps are diſſolved with great facility in ardent ſpirit, with which they combine more readily than with water. None of the metals, nor their calces, are acted upon by this fluid. Reſins, eſſential oils, camphor, bitumen, and various other ſubſtances, are diſſolved with great facility in ardent ſpirit, from which they may be precipitated by the addition of water.

According to the experiments and deductions of Lavoiſier and other modern chemiſts, the vinous fermentation by which ardent ſpirit is produced is an operation of conſiderable ſimplicity. This author, in his Elements of Chemiſtry, has even ventured to tabulate the whole of the reſults; which, if repeated and ſufficiently varied, would no doubt greatly advance our knowledge in this department of ſcience. I ſhall conclude the preſent article with his very perſpicuous explanation of this proceſs, retaining in juſtice to him the terms of the modern nomenclature, which are here but few, and are explained under our article Nomenclature.

The manner in which wine, cyder, mead, and all the liquors formed by the ſpirituous fermentation, are produced, is well known to every one. The juice of grapes or of apples being expreſſed, and the latter being diluted with water, they are put into large vats, which are kept in a temperature of at leaſt 54.5° of the thermometer. A rapid inteſtine motion or fermentation very ſoon takes place, numerous globules form in the liquid and burſt at the ſurface; when the fermentation is at its height, the quantity of gas diſengaged is ſo great as to make the liquor appear as if boiling violently over a fire. When this gas is carefully gathered, it is found to be carbonic acid, or fixed air free from admixture with any other ſpecies of air or gas, but uſually containing a portion of ardent ſpirit.

When the fermentation is completed, the juice of grapes is changed, from being ſweet and full of ſugar, into a vinous liquor, which no longer contains any ſugar, and from which we procure by diſtillation an inflammable liquor, known in commerce under the name of ſpirit of wine.

This operation is one of the moſt extraordinary in chemiſtry. We muſt examine whence proceed the diſengaged carbonic acid and the inflammable liquor produced, and in what manner a ſweet vegetable oxyd becomes thus converted into two ſuch oppoſite ſubſtances, whereof one is combuſtible and the other eminently the contrary. To ſolve theſe two queſtions it is neceſſary to be previouſly acquainted with the analyſis of the fermentable ſubſtance, and of the products of the fermentation.

We may lay it down as an inconteſtable axiom, that in all the operations of art and nature, nothing is created; an equal quantity of matter exiſts both before and after the experiment; the quality and quantity of the elements remain preciſely the ſame; and nothing takes place beyond changes and modifications in the combinations of theſe elements. Upon this principle the whole art of performing chemical experiments depends: we muſt always ſuppoſe an exact equality between the elements of the body examined, and thoſe of the products of its analyſis.

Hence, ſince from muſt of grapes we procure alcohol and carbonic acid, Lavoiſier concludes he has undoubted right to ſuppoſe that muſt conſiſts of carbonic acid and of alcohol: but his tranſlator juſtly remarks, that in this aſſertion the conſequences do not ſtrictly follow from the premiſes; becauſe from the muſt of grapes we procure carbonic acid and alcohol, it is a neceſſary conſequence that the original muſt contains the conſtituent elements of carbonic acid and alcohol, but not that theſe products of fermentation are already formed. From theſe premiſes we have two methods of aſcertaining what paſſes during vinous fermentation: either by determining the nature of, and the elements which compoſe, the fermentable ſubſtances, or by accurately examining the products reſulting from fermentation; and it is evident that the knowledge of either of theſe muſt lead to accurate concluſions concerning the nature and compoſition of the other. From theſe conſiderations it became neceſſary, accurately to determine the conſtituent elements of the fermentable ſubſtances; and for this purpoſe he did not make uſe of the compound juices of fruits, the rigorous analyſis of which is perhaps impoſſible, but made choice of ſugar, which is eaſily analyſed. This ſubſtance he ſtates to be true vegetable oxyd with two baſes, compoſed of hydrogen and carbon, brought to the ſtate of an oxyd by means of a certain proportion of oxygen; and theſe three elements are combined in ſuch a way, that a very ſlight force is ſufficient to deſtroy the equilibrium of their connection. By a long train of experiments, made in various ways, and often repeated, he aſcertained that the proportions in which theſe ingredients exiſt in ſugar are, nearly eight parts of hydrogen, ſixty-four parts of oxygen, and twenty-eight parts of carbon, all by weight, forming one hundred parts of ſugar.

Sugar muſt be mixed with about four times its weight of water, to render it ſuſceptible of fermentation; and even then the equilibrium of its elements would remain undiſturbed, without the aſſiſtance of ſome ſubſtance to give a commencement to the fermentation. Lavoiſier's tranſlator, however, remarks here, that this is not ſtrictly true; for, eſpecially in warm weather, all ſyrups are apt to run into fermentation, unleſs very rich of the ſugar, and carefully preſerved. At the ſame time this ſpontaneous fermentation is not ſo regular as when aſſiſted by yeaſt, and is apt to become in part acetous before completing the vinous proceſs.

The commencement of the fermentation is accompliſhed by means of a little yeaſt from beer; and when the fermentation is once excited, it continues of itſelf until completed. Lavoiſier uſually employed ten pounds of yeaſt, in the ſtate of paſte, for each hundred pounds of ſugar, with as much water as is four times the weight of the ſugar. The following is the reſult of his experiments, exactly as they were obtained, preſerving even the fractions produced by calculation.

TABLE I. *Materials of Fermentation.*

		lbs.
Water	— — —	400
Sugar	— — —	100
Yeaſt in paſte, 10 lbs. compoſed of	Water —	7,2391493
	Dry yeaſt —	2,7608507
	Total	510 lbs.

Table II. *Conſtituent Elements of the Materials of Fermentation.*

407.2391493 lbs. of water, compoſed of	Hydrogen —	61,0858724
	Oxygen —	346,1532769
100 lbs. of ſugar, compoſed of	Hydrogen —	8
	Oxygen —	64
	Carbon —	28
2.7608507 lbs. of dry yeaſt, compoſed of	Hydrogen —	,2900716
	Oxygen —	1,6437457
	Carbon —	,7876519
	Azot —	,0393815
	Total weight	510 lbs.

Table III. *Recapitulation of theſe Elements.*

		lbs.	lbs.
Oxygen	of the water — —	340	411.7970226
	of the water in the yeaſt —	6,1532769	
	of the ſugar — —	64	
	of the dry yeaſt —	1.6437457	
Hydrogen	of the water — —	60	69.3759440
	of the water in the yeaſt —	1.0858724	
	of the ſugar — —	8	
	of the dry yeaſt —	0.2900716	
Carbon	of the ſugar — —	28	28.7876519
	of the yeaſt — —	0.7876519	
Azot of the yeaſt	— —	—	0.0393815
		In all	510 lbs.

Having thus accurately determined the nature and quantity of the conſtituent elements of the materials ſubmitted to fermentation, we have next to examine the products reſulting from that proceſs. For this purpoſe Lavoiſier placed the above 510lbs. of fermentable liquor in a proper apparatus, by means of which he could accurately determine the quantity and quality of gas diſengaged during the fermentation, and could even weigh every one of the products ſeparately, at any period of the proceſs he judged proper.

An hour or two after the ſubſtances are mixed together, eſpecially if they are kept in a temperature of from 66° to 73° of the thermometer, the firſt marks of fermentation commence: the liquor turns thick and frothy; little globules of air are diſengaged, which riſe and burſt at the ſurface; the quantity of theſe globules quickly increaſes, and there is a rapid and abundant production of very pure carbonic acid, accompanied with a ſcum, which is the yeaſt ſeparating from the mixture. After ſome days, leſs or more according to the degree of heat, the inteſtine motion and diſengagement of gas diminiſh; but theſe do not ceaſe entirely, nor is the fermentation completed for a conſiderable time. During the proceſs, 35.3458116 lbs. of dry carbonic acid are diſengaged, which carry along with them 13.9140625 lbs. of water. There remains in the veſſel 460.7401259 lbs. of vinous liquor, ſlightly acidulous. This is at firſt muddy, but clears of itſelf, and depoſits a portion of yeaſt. When we ſeparately analyſe all theſe ſubſtances, which is effected by very troubleſome proceſſes, we have the reſults as given in the following tables:

TABLE IV. *Products of Fermentation.*

35.3458116 lbs. of carbonic acid, compoſed of	Oxygen	25.4490017
	Carbon	9.8968099
408.9780816 lbs. of water, compoſed of	Oxygen	347.6314019
	Hydrogen	61.3466797
57.7016059 lbs. of dry alcohol, compoſed of	Oxygen, combined with hydrogen	31.3897570
	Hydrogen, combined with oxygen	5.5393880
	Hydrogen, combined with carbon	4.0390625
	Carbon, combined with hydrogen	16.7333984
2.5000000 lbs. of dry acetous acid, compoſed of	Hydrogen	0.1562500
	Oxygen	1.7187500
	Carbon	0.6250000
4.0940755 lbs. of reſiduum of ſugar, compoſed of	Hydrogen	0.3275825
	Oxygen	2.6201172
	Carbon	1.1463758
1.3804254 lbs. of dry yeaſt, compoſed of	Hydrogen	0.1450738
	Oxygen	0.8218317
	Carbon	0.3938802
	Azot	0.0196397
510 lbs.		510 lbs.

TABLE V. *Recapitulation of the Products.*

409.6308595 lbs. of oxygen contained in the	Water	347.6314019
	Carbonic acid	25.4490017
	Alcohol	31.3897570
	Acetous acid	1.7187500
	Reſiduum of ſugar	2.6201172
	Yeaſt	0.8218317
28.7954643 lbs. of carbon contained in the	Carbonic acid	9.8968099
	Alcohol	16.7333984
	Acetous acid	0.6250000
	Reſiduum of ſugar	1.1463758
	Yeaſt	0.3938802
71.5540365 lbs. of hydrogen contained in the	Water	61.3466797
	Water of the alcohol	5.5393880
	Combined with the carbon of the alcohol	4.0390625
	Acetous acid	0.1562500
	Reſiduum of ſugar	0.3275825
	Yeaſt	0.1450738
0.0196397 lbs. of azot in the yeaſt		0.0196397
510 lbs.		510 lbs.

In the calculation of theſe reſults, Lavoiſier has been exact even to minuteneſs; not that it is poſſible in experiments of this nature, actually to carry our accuracy ſo far; but as the experiments were made only with a few pounds of ſugar, and as, for the ſake of compariſon, he reduced the reſults of the real experiments to the quintal, or imaginary hundred pounds, he thought it neceſſary to leave the fractional parts precisely as produced by calculation.

When we conſider the reſults preſented by theſe tables with attention, it ſeems eaſy to aſcertain what occurs during fermentation. In the firſt place, out of the 100lbs. of ſugar employed, 4.0940755lbs. remain, without having ſuffered decompoſition: ſo that in reality we have only operated upon 95.9059245lbs. of ſugar; that is to ſay, upon 61.3797916lbs. of oxygen, 7.6724739 6lbs. of hydrogen, and 26.8536588 6lbs. of carbon. By comparing theſe quantities, we find that they are fully ſufficient for forming the whole of the alcohol, carbonic acid, and acetous acid, produced by the fermentation. It is not, therefore, neceſſary to ſuppoſe that any water has been decompoſed during the experiment, unleſs it be pretended that the oxygen and hydrogen exiſt in the ſugar already combined in that form. On the contrary, it has already been made evident that hydrogen, oxygen, and carbon, the three conſtituent elements of vegetable ſubſtances, remain in a ſtate of equilibrium, or mutual union with each other, which ſubſiſts ſo long as this union remains undiſturbed by increaſed temperature, or by means of ſome new compound attraction; and that then only theſe elements combine, two and two together, to form water and carbonic acid.

The effects of the vinous fermentation upon ſugar are thus reduced to the mere ſeparation of its elements into two portions: one part is oxygenated at the expence of the other, ſo as to form carbonic acid, while the other part, being diſoxygenated in favour of the former, is converted into the combuſtible ſubſtance called alcohol; therefore, if it were poſſible to re-unite alcohol and carbonic acid together, we ought to form ſugar. It is evident, that the carbon and hydrogen in the alcohol do not exiſt in the ſtate of oil, but that they are combined with a portion of oxygen, which renders them miſcible with water; wherefore theſe three ſubſtances, oxygen, hydrogen, and carbon, exiſt here likewiſe in a ſpecies of equilibrium or reciprocal combination; and in fact, when they are made to paſs through a red hot tube of glaſs, or porcelain, this union or equilibrium is deſtroyed; theſe elements become re-combined two and two, and water and carbonic acid are formed.

Lavoiſier, in his firſt Memoirs on the formation of water, had advanced that it was decompoſed in a great number of chemical experiments, and particularly during the vinous fermentation. He then ſuppoſed that water exiſted ready formed in ſugar; but ſubſequent experiments convinced him that ſugar only contains the elements proper for compoſing it.

He concludes his remarks upon vinous fermentation by obſerving, that it furniſhes us with the means of analyſing ſugar, and every vegetable fermentable matter. We may conſider the ſubſtances ſubmitted to fermentation, and the products reſulting from that operation, as forming an algebraic equation; and, by ſucceſſively ſuppoſing each of the elements in this equation unknown, we can calculate their values in ſucceſſion, and thus verify our experiments by calculation, and our calculations by experiments, reciprocally. He adds, that he has often ſucceſsfully employed this method for correcting the firſt reſults of his experiments,

periments, and directing him in the proper road for repeating them to advantage.

SPIRIT OF LIBAVIUS. The ſame thing as the ſmoking liquor of Libavius; for which ſee the article TIN.

SPIRIT OF NITRE. See NITROUS ACID. In the ſhops the purer nitrous acid is called ſpirit of nitre, and the leſs pure uſed by artiſans, is called aqua fortis. Some authors aſſert that the common aqua fortis being diſtilled from impure nitre, and containing marine acid, has in many caſes the effect of an aqua regia. We have already remarked that the refiners purify their aqua fortis by adding a ſmall portion of the nitrous ſolution of ſilver, the metallic part of which combining with the marine acid falls down in the form of luna cornea.

SPIRIT OF SALT. See MARINE ACID.

SPIRIT OF SULPHUR. The volatile vitriolic acid. See ACID VITRIOLIC, alſo SULPHUR.

SPIRIT OF VENUS. The acetous acid diſtilled from the cryſtals of verdigriſe without addition. It appears to be in the aerated ſtate, and accordingly is much more active than ordinary acetous acid. It is totally inflammable.

SPIRIT OF VINEGAR. The common acetous acid, or diſtilled vinegar.

SPIRIT OF VITRIOL. This name has been given to the firſt portions of acid which come over in a diluted ſtate, when vitriolic acid is diſtilled or concentrated. It has alſo been applied to every other weak vitriolic acid.

SPIRIT VOLATILE OF SAL AMMONIAC. The volatile alkali which comes over in a cauſtic ſtate combined with water in the diſtillation of ſal ammoniac with ſlaked-lime, was originally called by this name. See ALKALI VOLATILE.

SPIRIT OF WINE. See SPIRIT ARDENT.

SPIRITUS RECTOR. Boerhaave and other chemiſts give this name to a very attenuated ſubtle principle, in which the ſmell of odorant bodies peculiarly reſides.

To obtain the ſpiritus rector from odoriferous ſubſtances, theſe matters are to be diſtilled in the cucurbit or body of an alembic placed in a water bath, with a very gentle heat, that is from one hundred to one hundred and ten degrees of heat, till we perceive what riſes in diſtillation has little or no ſmell.

The principle of ſmell in bodies is in general too ſubtle and too fugacious to be obtained alone and pure by any method whatever. Accordingly, it riſes by means of the water contained in ſubſtances diſtilled in order to procure it, and is diſperſed and overwhelmed in water. If the odoriferous matters from which the ſpiritus rector is required to be procured were abſolutely dry, and contained no other volatile principles, a little water or ſpirit of wine ought neceſſarily to be added, to furniſh a kind of baſis to this ſpirit, which would otherwiſe be diſſipated and evaporated, ſo that it could not be collected.

This principle of the ſmell of bodies is miſcible with water, with ſpirit of wine, and with oils. It ſeems however to be of different natures, according to the ſubſtances which furniſh it. Its properties ſhew that it is in general compoſed of an inflammable principle, and of a ſaline ſubſtance, both extremely attenuated. But the ſpiritus rector of ſome ſubſtances appears to be more of a ſaline, and that of others more of an oily nature.

All matters, the ſmell of which is quick, pungent, and which do not affect the brain and nervous ſyſtem, as the acrid, cruciform plants, and ſubſtances which undergo the acid fermentation, contain a ſpiritus rector, probably more ſaline than oily.

Thoſe on the contrary whoſe ſmell is ſweet, nauſeous or ſtrong, without acrimony or pungency, and which affect the head by curing or occaſioning hyſterical or convulſive accidents; ſuch as ambergriſe, muſk, caſtor, burnt coffee, opium, narcotic plants, camphor, all aromatic plants, and laſtly, the ſubſtances which undergo the ſpirituous fermentation; have, according to all appearance, a ſpiritus rector which partakes of the nature of oil. For, beſides that the effects produced by theſe ſubſtances are ſimilar to thoſe of the vapour of charcoal, the ſpiritus rector of ſome of them is really inflammable; as for inſtance, that of fraxinella, the exhalations from which form an atmoſphere that may be inflamed with a lighted taper.

The ſpiritus rector of all aromatic plants ſeems particularly to be aſſociated with their eſſential oils; at leaſt all theſe oils contain a good deal of it. To this principle they certainly owe their ſmell, and probably their volatility and thinneſs; for thoſe which from age, or from not having been preſerved in well cloſed veſſels, have loſt their proper ſmell, are at the ſame time much leſs thin and volatile, ſince they are no longer capable of being raiſed by the heat of boiling water; and beſides, the plants from which the ſpiritus rector has been obtained, furniſh little or no eſſential oil. See Oils (Essential).

The ſpiritus rector, even that of aromatic plants, although it be of an oily nature, is perfectly miſcible with water; which can only proceed from its great tenuity, or from the ſaline principle which enters its compoſition.

SPONGE. A ſoft, light, very porous, and compreſſible ſubſtance, readily imbibing water, and diſtending thereby. It is found adhering to rocks, particularly in the Mediterranean ſea, about the iſlands of the Archipelago. It is generally ſuppoſed to be a vegetable production: nevertheleſs ſome obſervations, made by Juſſieu, give room to ſuſpect that it is of animal origin. Chemical experiments favour this ſuppoſition: analyſed it yields the ſame principles with animal ſubſtances in general. Lewis ſays, that the volatile ſalt is in larger quantity than he obtained from any animal matter, except the bags of the ſilk-worm. On this ſalt ſeem to depend the virtues of the officinal Spongia uſta. Crude ſponge, from its property of imbibing and diſtending by moiſture, is ſometimes made uſe of as a tent for dilating wounds and ulcers.

It adheres ſtrongly to the mouths of wounded veſſels; and when retained by proper compreſſion, it has prevented conſiderable bleedings preferably to agaric, puff-ball, &c. On account of the ſaline matter contained in burnt ſponge, it has been uſed in ſcrophulous and other cutaneous affections, and in bronchocele.

SPUMA-MARIS. See Keffekil.

STAINING OF WOOD. The practice of ſtaining chiefly takes place in ſolid and inflexible bodies; and as it is performed with different views, it is alſo different in its nature. Here this kind only will be conſidered, in which a body is dyed on its ſurface, or the colour which it has already is changed. It has commonly this peculiarity, that the penetrating materials are only laid on the bodies with a bruſh; though the latter may alſo ſometimes be boiled or ſteeped in the former without receiving any detriment. It is uſed for wood, leather, horn, ivory, and various kinds of ſtones. In all theſe caſes attention ought to be paid to the natural compoſition of the bodies and their properties, as well as to the nature of the ſtaining materials.

For the ſtaining of wood, ſharp corroſive fluids muſt be uſed, ſuch as ſpirit of vitriol, aqua fortis, or a ſolution of blue or of green vitriol, according to the nature of the wood, or to the ſtate into which it has been put by means of art. Otherwiſe wood may be ſtained red, by previouſly ſoaking it in alum water, and then putting it into a decoction of brazil wood, in lime-water. It may be made blue with a ſomewhat diluted ſolution of indigo in vitriolic acid. It aſſumes a green colour in a decoction of verdigriſe, ſal ammoniac and vinegar; black in a decoction of galls, logwood, vitriol, filings of iron, and vinegar. For leather, on the contrary, theſe ſharp corroſive ſubſtances muſt be avoided; becauſe its durability will be deſtroyed by them. To give it a red colour, the ſkins, after being properly prepared, are dipped into a ſolution of tartar and common ſalt, then put into a bath of madder, tartar, alum, and calcined oyſter-ſhells, and ſometimes alſo at laſt into a ſimple decoction of brazil wood. Or the ſkins are ſteeped in alum water, and afterwards ſtained with a decoction of gum lac, brazil wood, alum and ſal ammoniac. They acquire a blue colour by being rubbed over with a ſolution of indigo and alum-water. They become yellow in a decoction of turmeric in lime-water; and green with ſap green diſſolved in lime-water. The above-mentioned baths may in like manner be uſed for horn and ivory; beſides which the diluted ſolutions of mercury, iron, copper, and ſilver may alſo be employed. Theſe latter liquors may likewiſe be laid upon all kinds of trinkets and toys made of agate. For the ſtaining of marble, coloured reſinous ſolutions in ſpirit of wine, or in ethereal oils, muſt be uſed; and, to promote the penetration of them into its ſubſtance, a little heat muſt be had recourſe to. In the ſame manner, alabaſter alſo may be ſtained with various colours, in particular red, with a decoction of brazil-wood and alum; blue with elder-berries and alum; yellow with ſaffron or turmeric, and other liquid colours of this kind. It is in a ſimilar kind of ſtaining that the effects of common writing-ink conſiſt. See Ink.

STALACTITES. Theſe are found ſuſpended from vaults, being formed by the oozing of water charged with calcareous particles, and gradually evaporating, leaving thoſe particles behind: this depoſition can ſcarce be called a cryſtallization, as the earthy particles ſcarcely appear to have been diſſolved, nor even very minutely divided, though this ſometimes happens; whereas tranſparent ſpars appear to have been formed from a ſolution in water, by means of the aerial acid. Stalactites are of a lamellar or granular texture, and either in a branchy form, or in that of perforated cones, or globular, and then called ſtalagmites, oolithes, piſolites, &c. Moſt of theſe ſtones contain a ſlight mixture of clay and calx of iron. And hence, they are of a gray, brown, yellow, or blackiſh colour.

STEATITES. A ſtone of the magneſian kind, conſiſting, according to Kirwan, of 80 parts ſilex, 17 magneſia, 2 clay, and 1 iron. It is always of a green or greeniſh colour, and ſo ſoft as to be ſcraped by the nail; of a ſoft ſoapy feel; its ſpecific gravity is from 2.433 to 2.78. It is not eaſily diffuſible in water, nor rendered ductile by mixture with it.

It does not effervеſce with acids, and is very ſlowly and only partially ſoluble in the three mineral acids.

In fire it hardens, but is infuſible per ſe, and becomes whiter. It is imperfectly melted by mineral alkali and microcoſmic ſalt, but more perfectly by borax. It is apt to corrode the crucibles.

STEEL. Under the articles Iron and Ores of Iron, much may be ſeen concerning the properties and applications of this uſeful metal, and its converſion into ſteel. In the preſent article, I ſhall avail myſelf of the valuable collection of facts brought together in the Encyclopedie Methodique ; not ſcrupling however, to make whatever abridgment or alteration may appear neceſſary.

The diſtinctive character of ſteel is, that when ignited and immediately plunged into cold water, it becomes much harder than it was before. Several of the methods of effecting this converſion have already been as amply deſcribed under the article IRON, as our limits would admit. Mr. Morveau diſcuſſes the five following queſtions. 1. Is every kind of iron capable of being converted into ſteel ? 2. By what means is this converſion to be effected ? 3. What are the proceſſes for reducing it back to the ſtate of iron ? 4. What are the effects of hardening, tempering, and annealing ſteel ? 5. What are the characters and properties which diſtinguiſh ſteel from iron ?

It is certain that every kind of iron is convertible into ſteel. This is mere matter of fact. But from the imperfection of the experiments yet made upon this metal, numerous though they are, it muſt be confeſſed that the various differences of quality in ſteel, which are extreme, ariſe much more from original differences in the iron made uſe of, than from any management in the manufacturing proceſſes ; and that theſe original differences have been very little inveſtigated, but exiſt more probably in the ore itſelf, than in the fuels, fluxes, or manipulations at the iron founderies and refineries. Bergman, in his treatiſe on the white ores of iron, has poſitively aſcribed the excellence of the white ſteel ore to a proportion of manganeſe which it contains. (* See Section X. of his Treatiſe, p. 230 Eng. Trans.) But we know of no direct experiments tending to aſcertain the advantages which might ariſe from an attempt to combine manganeſe with iron ; which would indeed require ſome addreſs in the chemiſt, on account of the extreme temperature requiſite for the fuſion of either metallic ſubſtance. Morveau is of opinion, that the manganeſe of the ſparry iron ores becomes vitrified, and aſſiſts in the more perfect fuſion and depuration of the iron, and in no other way ; and he is more confirmed in this opinion, by obſerving not only that good ſteel is procurable from ores of other kinds, but that Bergman himſelf examined ſeveral ſteels which did not afford more than one two-hundredth part of their weight of manganeſe ; a proportion which he thinks can hardly affect the nature of the ſteel, when ductile irons are capable of being combined with near one-third of their weight, without loſing their ductility.

Upon this argument I muſt remark, that the real converſion of iron into ſteel, by cementation, is effected by an addition of weight ſo ſmall, that inaccurate obſervers have been diſpoſed to aſſert that the gain is altogether inſenſible.

The Engliſh ſteel made by cementation, and afterwards fuſed, and ſold under the name of caſt-ſteel, in bars, plates, and other forms, poſſeſſes great reputation for its uniformity of texture, and other good qualities. I have been informed by various authorities, of which the reſpectability and connections are calculated to produce the moſt abſolute confidence, that all the prime ſteels of England are made from Swediſh iron, known in this country by the name of ſteel-iron, of three different marks, the firſt of which indicates the beſt quality, and the third the worſt ; and that the whole produce of this kind of iron is monopolized under a contract with Sweden, by two commercial houſes, one in London, and the other at Birmingham, the names of which were mentioned to me. Hence it ſeems probable that the uſeful art of ſteel-making might be much promoted by examining this material, and aſcertaining chemically, as well as mechanically, what may be the cauſe of its ſuperiority. By chemical examination, I mean the determination of its component parts, and by mechanical examination, whether thoſe parts are uniformly diſtributed through the whole maſs. For one of the greateſt imperfections of ſteel conſiſts in this unequal diſtribution, which produces a correſpondent inequality of hardneſs in the ſeveral parts of ſuch utenſils as may be made of it.

The converſion of iron into ſteel, either by fuſion, viz. the direct change of crude iron into ſteel, or by cementation of bar-iron, preſent many objects of intereſting enquiry. From various experiments of Bergman it appeared, that good crude iron, kept for a certain time in a ſtate of fuſion, with ſuch additions as appeared calculated to produce little other effect than that of defending the metal from calcination, became converted into ſteel with loſs of weight. Theſe facts are conformable to the general theory of Vandermonde, Monge and Berthollet, which is chiefly inſiſted on under the article Iron. For, according to their reſearches, it ſhould follow, that part of the plumbago of the crude iron was diſſipated, and the remainder proved to be ſuch in proportion as conſtitutes ſteel. The ſame chemiſt cemented crude iron with plumbago, and found that the regulus had loſt no weight. Morveau repeated the experiment with gray crude iron. The loſs of weight was little, if any. The regulus exhibited the black ſpot by the application of nitrous acid, as ſteel uſually does, but it did not harden by ignition and plunging in water. Hence, I conclude that it was ſcarcely altered. For crude irons alſo exhibit the black ſpot, and cannot by common management acquire the hardneſs of ſteel.

From the experiments of the three excellent chemiſts laſt mentioned, it appears that the gray crude iron conſiſts principally of iron, with as much plumbago as it can diſſolve in the ſtrong heat of the ſmelting furnace. They have ſhewn alſo, that it depoſits part of this addition when cooled in contact with an iron bar immerſed in the bath. This ſeparation muſt be general in the ordinary or gradual way of cooling, whence the gray colour muſt ariſe from the blue white colour of the iron mixed with the black of the plumbago. And this gray colour is alſo in a degree perceived when ſoft cloſe-grained ſteel is broken. Theſe circumſtances lead me to conclude, that hard ſteel may in a certain reſpect differ from that which is ſofter, by the intimate combination of a larger proportion of plumbago. This accounts for the whiter and more metallic aſpect of hardened ſteel, than of ſuch as is ſoft. For the former contains leſs of diſengaged plumbago. Hence alſo we may account for the greater hardneſs of ſteel which has been made quite hard, and then let down by tempering to a certain colour, than of ſteel merely heated to that colour, and plunged in water. For in the firſt method of hardening, a ſufficient degree of heat is given to produce combination between part of the diſengaged plumbago and the iron, which in the latter does not take place. If the plumbago be merely ſufficient to ſaturate all the iron at a moderate degree of ignition, the hardneſs will be conſiderable; but the ſteel will be eaſily degraded to the ſtate of iron by frequent ignition. Such ſteel in its hard ſtate will be very uniform in its texture, not exceſſively hard in its temper, but diſpoſed to take a very fine firm edge, which will not eaſily be broken or injured by violence. Theſe are accurately the properties of the Engliſh caſt ſteel, which is of ſo uniform a nature, as to be diſtinguiſhed by its conchoidal or glaſſy fracture. When the doſe of plumbago in ſteel is greater, it will bear a greater heat without degradation, inſomuch that it may be welded

welded like iron. Its hardneſs will alſo be capable of a higher degree; and if this degree produced by a ſtronger ignition be not given, the edge of the tool will never become fine and ſmooth; and even at this higher degree, with all the advantage of ſubſequent tempering, it will be leſs ſmooth than that of the caſt ſteel, and more diſpoſed to break. Steel of this kind is better adapted for the conſtruction of hammers, vices, hatchets, leather-cutters knives, and other inſtruments wherein the edge is either ſtout, or ſudden blows unneceſſary, or the conſtruction demands frequent heating and welding.

By purſuing this train of reflection, it will follow that, ſince crude iron differs from ſteel only in the ſuperabundance of plumbago, it ought to be capable of extreme hardneſs, if ignited to that degree which is requiſite to combine the greater part of this plumbago with the iron, and then ſuddenly cooled. This is accordingly found to be the caſe. If the gray crude iron, commonly diſtinguiſhed by our founders by the name of ſoft metal, be heated to a white heat, and then plunged in water, it becomes very hard, much whiter, denſer, and more metallic in its appearance; and will bear a pretty good edge fit for gravers, for the uſe of turners in iron or ſteel. In theſe tools the angle of the planes which form the edge is about 45°. The hardneſs of this kind of iron is not conſiderably diminiſhed but by ignition continued for a length of time, which is a fact alſo conformable to what happens in ſteel. For the caſt ſteel will be ſoftened nearly as much by annealing to the ſtraw colour, as the harder ſteels are by annealing to a purple or full blue.

Some of our artiſts have taken advantage of this property of ſoft crude iron in the fabrication of axles and collars for wheel-work; for this material is eaſily filed and turned in its ſoft ſtate, and may afterwards be hardened ſo as to endure a much longer time of wear.

The founders who caſt wheels and other articles of mechaniſm are occaſionally embarraſſed by this property. For, as the metal is poured into their moulds of moiſtened ſand, the evaporation of the water carries off a great portion of the heat, and cools the iron ſo ſpeedily, as to render it extremely hard, white, and cloſe in its texture. This is moſt remarkable in ſuch portions of the metal, as have the greateſt diſtance to run from the git or aperture of reception. For theſe come in contact ſucceſſively with a larger portion of the ſand, and are therefore more ſuddenly cooled. I have ſeen the teeth of cog-wheels altogether in this ſtate, while the rim and other parts of the wheel remained ſoft. The obvious remedy for this defect is to increaſe the number of gits, and to have the ſand as dry as poſſible or convenient. In other articles this property has been applied to advantage, particularly in the ſteel rollers for large laminating mills, which Meſſrs. Vandermonde, Monge and Berthollet have ſuppoſed to be an over cemented ſteel. They are made by caſting the gray crude iron in moiſtened ſand, the contact of which gives the hard ſteel temper to the outſide ſurface, for the depth of more than half an inch. I have no doubt but that the iron-maſters pay conſiderable attention to the quality of the iron, and perhaps to the degree of heat and moiſture of the ſand in this operation, in order that the hardneſs may be ſuch as to yield to the turning tool; and I likewiſe underſtand, that a conſiderable number crack longitudinally in the cooling, a loſs which in all probability ariſes from the difference of contraction between the hard and ſoft parts.

In the experiments of Rinman, a bar of caſt iron being placed over the fire of a ſmelting furnace was almoſt fuſed. It was obſerved in breaking it, that the ſide neareſt the fire had become ſoft iron to the depth of one ſixteenth of an inch; that the reſt was ſteel, excepting the upper part expoſed to the air, which remained in the ſtate of crude iron.

I muſt refer to the Encyclopedie for a conſiderable enumeration of experiments relative to the cementation of iron with various materials, and alſo to ſuch as relate to the return of ſteel to the ſtate of iron. It appears in general, as might be expected, that iron by a ſufficient continued heat in cloſed veſſels, in contact with coaly matter, becomes ſteel; but that if ſuch matter be not preſent, the effect does not take place; and even the ſtate of ſteel, if poſſeſſed by the iron, that is to ſay, its power of hardening by moderate ignition, goes off.

A variety of facts concerning the hardening and ſoftening of ſteel are collected by M. Morveau, the moſt intereſting of which I ſhall here ſubjoin.

The general facts are related under our article IRON. According to Reaumur, that part of the ſteel which was hotteſt at the time of immerſion in the water will be the hardeſt; whence it has been thought a fair concluſion, that the hardneſs of ſteel is the greater, the ſtronger the ignition, and the more ſpeedy the cooling. Nevertheleſs, the celebrated Rinman deduces a very different conſequence; namely, that the ſteel which is naturally the hardeſt is that which requires the leaſt heat, and that the beſt temper for each kind of ſteel is that produced by the loweſt degree of heat ſuitable to that peculiar kind. Hence various methods have been propoſed to aſcertain the degree of heat moſt advantageous to any particular ſample of ſteel. They are all reducible to that of igniting one end of a bar to a white heat, and plunging it into water. The hardneſs of the ſeveral parts may then be aſcertained by examination.

It appears to me, that the conſiderations on which the firſt-mentioned general rule is founded, are rather of a complicated nature. If it be true, as conjectured above, that the hardneſs of ſteel depends principally on the intimate combination of its plumbago; it will follow that the utmoſt hardneſs any ſteel is capable of will be produced by a degree of heat ſufficient to effect this purpoſe, and that any ſuperior degree will only degrade the quality of the ſteel; and conſequently, that the general rule will apply only to heats inferior to this maximum. It may alſo happen, when the maſs of water is not conſiderable, though I doubt the fact when the quantity is large, that the heating of the water, and the production of inflammable air, may ſo far modify the rate of cooling, as even to render it leſs ſudden than might have happened with an inferior degree of ignition. Lavoiſier has remarked, that the converſion of iron into the hard brittle ethiops, when water is decompoſed (ſee WATER), may perhaps be of the ſame nature as the hardening of ſteel. There is another fact, which is of great conſequence, and may perhaps afford the principal ground for Rinman's apparent exception to the general rule concerning the hardening of ſteel. Hardneſs is that property of bodies by which they reſiſt indentation, and rather break than bend, or ſuffer contuſion. It is the oppoſite to ſoftneſs. Tenacity, which is very frequently confounded with hardneſs, is not the property by which they reſiſt indentation, but ſeparation of their parts. It is the oppoſite to friability or brittleneſs. Now, that ſteel, in common language, is ſaid to be the hardeſt, which unites moſt eminently the properties of hardneſs and tenacity. But the effect of heat and ſudden cooling is directly oppoſite in theſe two reſpects. Soft ſteel is the moſt tenacious, but the leaſt hard. The operation of the temper diminiſhes its tenacity, and increaſes its hardneſs progreſſively unto the maximum of heat the ſteel is formed to bear. There will be no difficulty then in conceiving that the beſt ſtate of ſteel relative to any particular uſe, will be at ſome preciſe degree between the ſofteſt and hardeſt qualities. Thus for ſprings, much tenacity and moderate hardneſs are required. For chiſſels and ſimilar tools which operate by a blow, a greater hardneſs may be admitted. Razors, knives, and ſuch tools as effect the intended purpoſe by a gradual ſtroke, will be ſtill more valuable the harder they are; but even in theſe the tenacity muſt not be too much diminiſhed, otherwiſe the edge will be liable to break. Files are perhaps of all tools ſuch as admit the greateſt hardneſs; but in theſe, it is far from being the utmoſt the ſteel is capable of receiving. It is found that the tenacity of ſteel is conſiderably increaſed by continued hammering to a certain point. But the whole effect of this hammering is taken off by ſtrong ignition. Good ſteel at a white heat may be rendered ſo brittle, that it breaks full as eaſily as a ſtick of the ſame dimenſions, and its texture is then found to be coarſe and large grained. As the ſubſequent annealing does not reſtore the effect of the hammering, nor bring the grain of the ſteel to the ſtate it would have poſſeſſed if a lower heat had been uſed at firſt; it is evident that the moſt uſeful hardneſs is produced by that degree of heat which is juſt ſufficient to effect the purpoſe. And accordingly, tools made of caſt ſteel, and intended to ſuſtain a good edge for cutting iron and other metals, are not afterwards annealed, but the ignition is carefully regulated at firſt. Annealing ought only to be uſed where conſiderable ſoftneſs is required.

Rinman affirms that ſteel does not harden when cooled in a cloſe cylinder, or even in a veſſel purged of air. Not having his work in my poſſeſſion, I find ſome difficulty in conceiving how the experiment could be made, ſo as to obviate all objections relative to loſs of time, unleſs the burning glaſs and receiver of an air-pump were uſed. Reaumur alſo found that a ſmall piece of ſteel introduced red hot into a tube of glaſs full of mercury, which was immediately ſet upright ſo as to form an ordinary barometer with the vacuum at the top, continued as ſoft as if it had been cooled in the open air. Do theſe facts warrant the ſtrange concluſion, that the mere preſſure of the atmoſphere is concerned in the hardening of ſteel? It ſeems, nevertheleſs, that no other effect of the air could be tranſmitted to the ſteel, ſo inſtantaneouſly through a body of water. When we reflect on the effectual modifications which the ſmalleſt agitation, or even the preſence of light, have upon the arrangement of the parts of ſolid bodies in cryſtallization, we ſhall have leſs cauſe for wonder at the confirmation of theſe facts.

Iron may be hardened to a certain degree by ignition and plunging in water, but this effect is confined to the ſurface; except, as it very often happens, the iron contains veins of ſteel. Theſe are no ſmall impediments to the filing and working this material. It ſometimes likewiſe may happen, that the iron may have undergone a proceſs of the nature of caſe-hardening from the fuel. I have been informed by a workman, that ignited iron ſuddenly plunged into the ſoft leather of a ſhoe, becomes very hard on its ſurface, which muſt ariſe from an inſtantaneous effect of this kind.

The increaſe of dimenſions acquired by ſteel in hardening (mentioned in page 414) is ſuch, that in general ſuch pieces of work as are finiſhed ſoft, will not fit their places when hardened. Rinman found that bars of ſteel ſix inches long, ſix lines wide, and half an inch thick, were lengthened at leaſt one line after hardening by a whitiſh red heat, which is about one-ſeventieth of the linear dimenſions; and ſuppoſing the dilatation to be proportional, M. Morveau computes the bulks to be as 48 to 49. But the cubes of 72 lines and 73 lines are in proportion more nearly as 47 to 50. Various kinds of ſteel at different hardneſs muſt no doubt greatly differ in this reſpect. The ſpecific gravities as given by

Briſſon,

Briſſon, p. 366, art. Gravity Specific, afford a much leſs ratio. Rinman found by his experiments on two different kinds of fine cemented ſteel, whoſe ſpecific gravity was 7,991, that one after hardening gave only 7,553, and the other 7,708. Theſe numbers agree ſufficiently near with the experiment of the ſix-inch bar. Yet he once found Styrian ſteel augmented in denſity by hardening in the ratio of 7,822 to 7,782. Morveau found, with pieces of ſteel 28 lines long, that the increaſe of length by hardening was about the 350th part.

The fineneſs of grain in hard ſteel, as exhibited in its fracture, is various according to the quality of the metal, and the temper it has received. The harder the ſteel the coarſer the grain. But in like circumſtances, fine ſteel has the cloſeſt grain, and is ever the moſt uniform in its appearance. Workmen avail themſelves much of this indication. In general a neat curve lined fracture, and even gray texture, denote good ſteel; and the appearance of threads, cracks, or brilliant ſparks, denotes the contrary. But the management of the forging and other circumſtances of manufacturing will modify theſe indications; and the ſteel which is good for ſome purpoſes may be leſs ſuited to others.

The fluid in which ignited ſteel is plunged, is of great conſequence. All the facts ſeem reducible to theſe general concluſions. The hardneſs will be greater, 1. the hotter the ſteel is made, provided it be not decompoſed: 2. the more conſiderably its temperature is lowered in the cooling: 3. the ſhorter the time of cooling: and 4. the more favourable the fire or the cooling material may be to the ſteel-making proceſs. But the moſt uſeful combination of hardneſs and tenacity will be at a medium temperature in each kind of ſteel.

With regard to the firſt particular, little need be ſaid, but that the decompoſition of ſteel in heating will be prevented, and its ſurface ſomewhat improved, if it be bedded in charcoal, or the cementing compound, during the application of the heat. The ſecond and third, namely the quantity and ſuddenneſs of cooling, require an attention to the doctrine of HEAT, as explained under that article. The cooling will be more ſudden and effectual the greater the quantity of heat abſorbed in the ſame time. There are three circumſtances which favour this effect, namely, a very low temperature of the body to which the hot ſteel is applied; that it ſhall be a good conductor of heat; or that it ſhall aſſume either the fluid or elaſtic ſtate, which always demand a ſupply of heat for their maintenance. Thus it is found, that ſteel is more effectually hardened in cold than in warm water, and at like temperatures more effectually in mercury than in water. It may alſo be remarked, that theſe two fluids cool the ſteel by different energies. The water is partly converted into vapour, which carries off the heat, and leaves the fluid much leſs altered than mercury, which acts by its conducting property. This laſt fluid, not having evaporated in the proceſs, is found to have acquired a much more elevated temperature by the immerſion. Oil is found to harden the ſurface of ſteel much more than its internal part, ſo that it reſiſts the file, but is much leſs eaſily broken by the hammer. This effect ariſes from its imperfect conducting quality, and the elevated temperature it demands to be converted into the vaporous ſtate; to which we may alſo add, that a ſtratum of coal is formed round the ſteel from the burned oil, which ſtill more effectually prevents the tranſmiſſion of the heat. A remarkable inſtance of this nature preſented itſelf to my obſervation in hardening a ſmall piece of ſteel, two inches long, and a quarter of an inch diameter. At the time of ignition, the water neareſt at hand had been uſed with ſoap. The ſteel made very little noiſe when plunged in the water, and remained hot for a conſiderable time; but when taken out was found to be ſcarcely at all hardened. It was covered with coaly matter; which being cleared off, and the proceſs repeated with clean water, it became perfectly hard. The heat in both caſes was a low red heat, proper for caſt ſteel, which is not intended to be afterwards annealed. I have very little doubt, but that ardent ſpirit, and the eſſential oil of turpentine, which are good conductors of heat and very volatile, would render ſteel very hard, if their inflammability, and the little neceſſity there is for uſing them, were not an impediment to their application. Various artiſts avail themſelves of different ſubſtances for the immerſion of ignited ſteel. Some uſe urine, others water charged with common ſalt, nitre, or ſal ammoniac. Tallow and oil are uſed for ſuch works as are not required to be brittle, though very hard, the reaſon of which has juſt been mentioned; but tallow differs from oil in the heat which becomes latent for its fuſion; and accordingly, ſolid tallow is an excellent material for hardening drills and other ſmall articles. It has been found by Reaumur, that ſaline liquids produce rather more hardneſs than common water; and in particular, that aqua fortis poſſeſſes this property in an eminent degree, probably from its conducting power: the makers of files cover them with beer and common ſalt, which aſſiſt their hardening, and keep the ſurface from ſcorifying. The mucilage of the beer ſupplies a coaly matter; and the fuſed ſalt ſeems not only to form a varniſh in the fire and defend the ſteel, but may alſo produce cold, by its ſudden ſolution in the water at the time of immerſion. Very ſmall articles heated in a candle are found to be hardened perfectly by ſuddenly whirling them in the cold air; and thin bars or plates of ſteel, ſuch as the magnetic needle of a compaſs, acquire a good degree of hardneſs by being ignited, then laid on a plate of cold lead, and ſuddenly covered with another plate. Theſe would be unequally hardened, and bend, if plunged in water.

Mr. Duhamel, in the Encyclopedie, gives an ample account of the methods of making ſteel by the ancient way of fuſion from the ore, and the more modern way of cementation. We have treated conciſely of both under the article Iron, and in this place ſhall only add a few of the facts noted by this author concerning cementation. The Engliſh, who deſervedly poſſeſs the greateſt reputation in this work, have found that every ſpecies of iron is convertible into ſteel by cementation; but that good ſteel is not to be made except from iron of the beſt quality, which poſſeſſes a certain ſtiffneſs and hardneſs as well as malleability. Swediſh iron, as we have before remarked, is the beſt for this purpoſe. Mr. Duhamel tried a great number of the irons of France, Sweden and Spain. He found the ſecond to be the beſt; but he likewiſe obtained excellent ſteel, ſuperior to thoſe of Styria and Carinthia, which are the beſt German ſteels, by uſing certain iron made in France. But this iron was ſelected without fault, and in ſome inſtances, the loup or piece at the ſmelting furnace was fuſed and forged a ſecond time; a proceſs which, though attended with loſs of weight and additional expence, he recommends as abſolutely neceſſary for making ſteel iron from ores of indifferent quality. The white ſpathoſe iron ores afforded him the beſt iron for the purpoſe of cementation; and theſe alſo are the ores which afford the beſt ſteel by fuſion, in Styria, Carinthia, and Tyrol. He informs us, that the Engliſh uſe no other cement than mere charcoal, which he alſo finds perfectly adequate to the purpoſe; and moreover, that the quality of the ſteel is not affected by the different kinds of charcoal made uſe of. He remarks nevertheleſs, that it may be adviſable to add from one-fourth to one-third of wood aſhes, eſpecially where the iron is not of ſo good a quality as to afford ſteel poſſeſſing tenacity or body, as well as hardneſs. Theſe aſhes, which he uſed with ſucceſs, prevent the ſteel-making proceſs from being effected as rapidly as it would otherwiſe be, and give the ſteel pliability without diminiſhing its hardneſs. It is remarked, that in the caſe of this management, the bliſters on the ſurface of the ſteel are ſmaller and more numerous. He likewiſe tried ſea-ſalt. Fifty pounds of ſalt are ſufficient for a furnace of ſteel of twelve thouſand weight. The ſalt is pulveriſed, and ſprinkled on the bars of iron when put into the furnace. He found that this ingredient likewiſe contributes to give body to the ſteel. In the arrangement of the bars in the furnace, the cement is laid one inch thick at the bottom, and half an inch thick between each layer of iron. Our author affirms, that the proceſs would ſucceed equally well, if the thickneſs were a little more than a quarter of an inch. The thickneſs of the bars of iron is indifferent, but there ought not to be a great difference in this reſpect between bars cemented at the ſame time. The common thickneſs is a little more than half an inch. It is not adviſable that they ſhould be very broad in proportion to the thickneſs, as this figure is found to produce flaws and cracks in the direction of the length of the bar. The bars may be ſquare, or their breadth may conveniently be ſomewhat more than twice their thickneſs. The fire for cementation muſt be of conſiderable intenſity, and kept up until the converſion has perfectly taken place, which is aſcertained by proof bars, ſo diſpoſed as to be taken out from time to time. The cementation is finiſhed on the ſixth day; that is to ſay, it commonly laſts five times four-and-twenty hours. And accordingly, the workmen take one of the proofs out on the fifth day, which is forged, hardened, and examined by the fracture. If it break ſhort, and ſhew no indications of iron, the fire of the furnace is ſuffered to go out. But if it contains iron, the fire is kept up for twelve or twenty-four hours, accordingly as the quantity of fibrous iron may have proved greater or leſs in the firſt proof. A ſecond proof bar taken out at the proper time ſerves to direct them in the ſame manner with regard to their operations. By this management, the cementation is continued ſomewhat beyond the time requiſite for the entire converſion. For there is leſs inconvenience attending a ſlight degree of exceſs in the cementation, than would reſult from a portion of iron remaining in the ſteel. The charcoal after cementation is as black, and apparently in the ſame ſtate, as it was before. Mr. Duhamel moiſtened it, and applied it to the ſame uſe a ſecond time. It anſwered the purpoſe, but ſo much more ſlowly, that he objects to the uſe of it in manufactories. From this, as well as other circumſtances attending the ſteel-making proceſs, it ſeems advantageous at leaſt with regard to expedition, that the coals ſhould contain volatile matter. And hence the ſuperior advantages of animal coal, ſuch as the coal of leather, or the hoofs and horns of animals, imperfectly burned, which are uſed in caſe-hardening, though they may be leſs applicable to the longer proceſs of ſteel-making for various reaſons.

Mr. Duhamel adviſes to have two tilting hammers; one of the weight of one hundred and fifty pounds, and the other half that weight; the firſt, for the purpoſe of forging large work, and the latter ſmall bars for cutlers. He recommends another ſmall hammer of about twelve pounds for forging bars ſtill ſmaller, to make gravers, ſmall files, and the like. The ſteel muſt not be heated beyond the degree of cherry red for forging. The tilting hammers ſhould give at leaſt three hundred ſtrokes in a minute.

On this head, I muſt make a reflection, which perhaps may be of value to the manufacturer, though experience certainly affords the only means of determining the utility of propoſed alterations in the implements or utenſils. When a hammer ſtrikes with a certain momentum, the change of figure produced by the blow willl be greater, the more of velocity and the leſs of maſs poſſeſſed by the hammer. It ſeems therefore, in the application of mechanic force, that in moſt caſes the expenditure would prove more profitable, if an extreme velocity were given to a ſmall weight, the face of the hammer remaining the ſame, than if a larger weight were moved proportionally ſlower. And ſo likewiſe, it ſhould appear, that more work would be done by a certain number of ſwift blows, than by twice the number with only half the ſwiftneſs. When the uſual number of ſtrokes is three hundred in a minute, or five in a ſecond, the velocity cannot be conſiderable, even when aſſiſted by a back ſpring, or other contrivance. It would therefore at leaſt be worth trying in ſituations where the power is limited, as in the caſe of a ſmall ſtream of water, or ſteam engine, whether the weights and velocities of the hammers may not be altered with profit. An ingenious mechanic would find no difficulty in contriving a ſimple apparatus, by which theſe correſpondent alterations might be made at pleaſure, accordingly as the nature of the work or other circumſtances might demand.

The caſt ſteel of England is made by a proceſs which the manufacturers keep a ſecret. Mr. Duhamel gives the following account of it: A crucible about ten inches high, and ſeven in diameter, is filled with ends and fragments of the crude ſteel of the manufactories, and the filings or fragments of ſteel works. Magellan affirms, that they buy up broken tools at Sheffield or elſewhere for this purpoſe. They add a flux, the component parts of which are carefully concealed. It is probable, however, that the ſucceſs does not much depend upon this flux, which, from the quality of the caſt ſteel itſelf, may be preſumed to be of the nature of a ſteel cement. This crucible is placed in a wind furnace, like that of the founders, but ſmaller, becauſe intended to contain one pot only. It is likewiſe ſurmounted by a cover and chimney to increaſe the draft of air. The furnace is entirely filled with coke or charred pit-coal. Five hours are required for the perfect fuſion of the ſteel. It is then poured into long ſquare, or octagonal moulds, each compoſed of two pieces of caſt iron fitted together. The ingots when taken out of the moulds have the appearance of caſt iron. It is then forged in the ſame manner as other ſteel, but with leſs heat and more precaution; becauſe more liable to break.

This caſt ſteel is almoſt twice as dear as other good ſteel. Mr. Duhamel ſays, that it is not proper for all kinds of work, particularly thoſe which require much tenacity, as well as hardneſs to reſiſt violent blows and ſtrains; but it is good for razors, knives, and all toys and ſmall work which require an exquiſite poliſh. It does not ſeem, however, that the tenacity of this ſteel is inferior to that of the beſt of the other kinds, and its uniformity of texture is for many works an invaluable advantage. It is daily more and more uſed in England, but muſt neceſſarily be excluded from many works of conſiderable ſize, on account of the facility with which it is degraded in the fire, and the difficulty of welding it, which cannot be done in the common way. I have been informed that the faces of anvils and broad hammers, for the uſe of ſilver-ſmiths and other artiſts, have been made of caſt ſteel and welded to iron by a particular management, which conſiſted in ſubſtituting between the iron and the ſteel another kind of ſteel in the form of filings, or a thin plate. The ſteel plate intended for the face was made as hot as could be done with ſafety, and the iron being at the ſame time brought to the welding heat, was applied to the ſteel, and quickly united by hammering.

STONE. An indurated hard maſs of earth. Stones were formerly diſtinguiſhed from earths in claſſification. It does not ſeem, however, that any uſeful purpoſe is likely to be anſwered by this diſtinction. For a ſtone is a maſs of earth of conſiderable magnitude, ſand is a collection of ſmall ſtones, and earth in the pulverulent ſtate may be conſidered as a fine ſand. To the chemiſt, whoſe attention is chiefly taken up with the component parts of bodies, theſe variations of dimenſion are comparatively of little conſequence.

STONES PRECIOUS. See Precious Stones.

STONES or CALCULI, found in the bodies of animals. Before the experiments of Scheele and Bergman were made, little was known of the conſtitution of the ſtone of the bladder; excepting that alkalis being conſidered as remedies for this diſorder, afforded a ſlight indication of its acid nature. Theſe two great chemiſts ſeparately undertook to make a more accurate examination into its component parts.

The ſtone of the bladder is formed for the greateſt part of a peculiar concrete acid, very ſparingly ſoluble in water. If the ſtone be boiled in this fluid, near three grains out of a thouſand are taken up. The ſolution reddens the tincture of turnſole, but moſt of the acid is depoſited in ſmall cryſtals.

According to Scheele, water at length completely diſſolves it. By deſtructive diſtillation it affords volatile alkali, and a brown ſublimate, which becomes white by a ſecond ſublimation, and is the concrete volatile acid. Seventy grains of the calculus afforded him in this operation twenty-eight grains of ſublimate, and there remained in the retort twelve grains of black coal, which preſerved its colour in the open air upon a red hot iron.

The ſame chemiſt likewiſe obſerved: 1. That the vitriolic acid does not diſſolve the calculus unleſs concentrated and boiled, in which caſe the volatile vitriolic acid flies off. 2. That the marine acid does not act upon it. 3. That nitrous acid acts upon it even without heat; that it diſſolves it entirely by the aſſiſtance of heat, with the emiſſion of red vapours; and that the elaſtic fluid which comes over, precipitates lime from water. 4. That this nitrous ſolution always manifeſts a diſengaged acid; that it leaves a bright red ſpot upon the ſkin, and becomes of a blood red colour when much concentrated, which colour diſappears on the addition of a few drops of nitrous acid. 5. That this nitrous ſolution is not precipitated by muriated ponderous earth, and occaſions no change in metallic ſolutions. 6. That this ſolution is not rendered turbid by the acid of ſugar. 7. That the addition of fixed alkali ſimply produces a yellow colour; that when the alkali is abundant, the mixture aſſumes a roſe colour by digeſtion, and colours the ſkin; and that in this caſe it precipitates martial vitriol of a black colour; vitriol of copper, green; ſilver, gray; and corroſive ſublimate, zinc, and lead, white. 8. That lime water affords a white precipitate with this ſolution; that this precipitate well edulcorated is ſoluble without efferveſcence in the nitrous and marine acids; that the liquor always manifeſts a diſengaged acid, and takes fire when evaporated to dryneſs; that the precipitate treated in cloſe veſſels leaves a black light reſidue, ſoluble in acids with efferveſcence. 9. That the calculus is not attacked by mild vegetable alkali, even boiled, but is very ſoluble in the cauſtic alkali; that this ſolution is yellow, does not become turbid by lime water, is precipitable by all the acids, fixed air not excepted, decompoſes metallic ſolutions,

lutions, and emits a ſmell of volatile alkali when the fixed alkaline ſolvent is ſuperabundant. 10. That cauſtic volatile alkali likewiſe diſſolves the calculus, but the quantity required is large. 11. That a thouſand grains of lime water diſſolved 53.7 by mere digeſtion, of which part at leaſt was precipitated by the addition of an acid. 12. and laſtly, That all urine, even that of infants, holds a ſmall portion of this matter in ſolution; that the brick-coloured depoſition from urine in fevers is of this nature; that it ſeparates by mere cooling, and is taken up again by heat.

From theſe experiments ſeveral important inferences may be deduced with regard to the compoſition of the calculus and the properties of its acid. It certainly contains volatile alkali, though in ſmall quantity. Its moſt conſiderable ingredient is the acid, which exiſts ready formed. Scheele admits of the exiſtence of an animal gelatinous matter, though it ſeems, from the ambiguity attending the combuſtion or decompoſition by nitrous acid or deſtructive diſtillation, it muſt be difficult to aſcertain the quantity. It contains no calcareous earth, according to the teſt of acid of ſugar, though Bergman by the application of vitriolic acid to the nitrous ſolution ſeparated a ſmall portion. Mr. Morveau remarks that it would be wrong to draw general concluſions from the experiments of the Swediſh chemiſts, becauſe other calculi may differ in their properties and component parts; more eſpecially as he was informed by Mr. Tennant of the Royal Society of London, that among the calculi on which he had made experiments, he found ſome that loſt only two thirds of their weight by heat, and the reſidue formed a tranſparent glaſs which became white by cooling. From theſe appearances, it ſeems that a conſiderable quantity of phoſphorated lime, with ſuperabundance of acid, was ſublimed.

The properties of the acid of the ſtone of the bladder are, that it is concrete, very ſparingly ſoluble in water, partly decompoſable by diſtillation, and partly ſublimable.

This acid, when treated with the nitrous acid, is not ſimply diſſolved. The maſs which remains, as Bergman informs us, after evaporation to dryneſs is very different from the concrete acid. It is of a dull red colour; attracts the humidity of the air; a very ſmall portion of it gives a roſe colour to water; in a word, it ſtains the ſkin, bones, and even glaſs, like the nitrous ſolution. This great chemiſt remarks, that theſe phenomena are much more likely to ariſe from a change in the animal acid than from a reſidue of the nitrous. But Morveau juſtly adds, that the nitrous acid is itſelf decompoſed, and produces a higher degree of acidification in the animal matter, by the communication of vital air in the ſame manner as that principle produces a change in the marine acid.

This acid unites to earths, alkalis, and metallic calces. It appears to prefer the alkalis to the earths, but yields theſe baſes to the weakeſt acids, even fixed air; in which particular it differs from all the other acids but the Pruſſian, with which it cannot be confounded.

M. Fourcroy has inſerted in the ſixteenth volume of the Annales de Chimie a comparative analyſis of the different animal and vegetable concretions intended to form the article *calculs* in the Encyclopedie. The firſt part of this memoir is contained in the number for January 1793. It chiefly relates to animal concretions. The remainder has not come to hand, on account, as I ſuppoſe, of the interruption of communication produced by the troubles in France. One of the greateſt difficulties this chemiſt found, conſiſted in making a collection of the different concretions in the human body, and ſtill more with regard to the calculi in the different ſpecies of animals. In order therefore to communicate a notion of the imperfect ſtate of ſcience in this reſpect, and the importance of the neceſſary reſearches, he ſpeaks rapidly in the alphabetic order of the principal calculi hitherto known. Some facts and even ſome analyſes peculiar to himſelf are inſerted; but the greater number of articles exhibit little more than an indication of what remains to be done.

The biliary calculi are of two kinds, relative to the proportion of their ingredients. One kind is entirely compoſed of a foliated brilliant cryſtalline ſubſtance, analogous to ſpermaceti; the others, with a greater or leſs quantity of this ſubſtance which conſtitutes the baſis or nucleus, contain the thickened bile or extract of bile, in the midſt of which the firſt-mentioned ſubſtance appears to have irregularly cryſtallized. We are indebted to M. Fourcroy for what we know concerning the biliary calculi, but much remains yet to be done in this reſpect. He ſtates a part of the objects of reſearch by aſking, How is the abdominal fat converted into a ſubſtance reſembling ſpermaceti? What is the cauſe and mode of this converſion? By what ſigns can we aſcertain its exiſtence in men? What are the indications of this diſpoſition in the biliary paſſages; and particularly, What are the means of oppoſing it? What difference may exiſt between the human biliary calculi and thoſe of other animals? It is known that oxen and ſheep are ſubject to this diſorder. The butchers find biliary ſtones in the inteſtines and gall bladder of oxen, particularly at the end of autumn and during the winter. It is ſaid that they are uſed as a pigment; but no comparative analyſis has yet been made to diſtinguiſh them from the human gall-ſtones.

The liver is often filled with hard and ſolid concretions, which are the conſequence of obſtruction. Theſe have not yet been examined. Fourcroy ſeems diſpoſed to conjecture that they may be of the ſame nature as that of the concretions found in the bladder.

Inteſtinal calculi are thoſe which are found in the inteſtines of man or other animals, whether diſcharged from other organs or viſcera, or formed in the inteſtinal canal. In man they are almoſt always gall-ſtones, and are ordinarily diſcharged by the anus. Calculi formed by the induration or cryſtallization of the contents of the inteſtines, are extremely rare in the human ſyſtem; but much more common in animals. Our author examined one of theſe concretions taken from the inteſtinal canal of a horſe. Its colour was gray; it appeared to be formed of rays diverging from the centre to the circumference. Its figure was round, conſiderably regular; its diameter five inches, and its weight five pounds. When ſawed in half, it was ſeen that its parts were ſo arranged round a common centre, as to diverge in all directions, and form a ſphere of eighteen inches circumference. The centre of this ſphere exhibited certain cavities which contained fragments of vegetable matters, ſuch as ſtraw, hay, and oats; which emitted the ſmell of theſe ſubſtances already altered.

M. Fourcroy examined this ſubſtance by treatment with water hot and cold, with the pure mineral alkali, by the action of heat, the three mineral acids, the aerated marine acid, deſtructive diſtillation, and diſtillation with charcoal. For the ſake of brevity the reſults are here omitted; but they produce the concluſion that the calculus was a triple ſalt, compoſed of about two parts phoſphorated magneſia, one part phoſphorated volatile alkali, and one part water, beſides certain traces of vegetable and animal admixture.

M. Fourcroy offers ſeveral conjectures relative to the formation of this concrete ſubſtance. He demands whether its principles were formed in the viſcera of the

horſe;

horſe; and on that ſuppoſition, whence did they derive their elements? for they themſelves are compounds. By what means did the magneſia, a ſubſtance ſo rarely met with among animal matters, become part of this compound? Can it be ſuppoſed to have originated in the entrails of the animal? and if ſo, by what proceſs? Is there any ground for the looſe and remote hypotheſis, that it may be a modification of lime, which is ſo univerſally diffuſed in animals? With regard to the phoſphoric acid, though we are far from poſſeſſing a good ground of eſtimate of its quantity in the animal œconomy, yet it is eaſy to conceive that it may have been collected in the inteſtines, and united in a courſe of time with the magneſia and volatile alkali. Perhaps the magneſia may have been given to the animal as a remedy for ſome inteſtine diſorders. This ſuſpicion appears the moſt probable to Fourcroy; though it ſeems, according to him, to include the ſuppoſition that the magneſia muſt have remained a long time in the animal, and prevented its ordinary evacuations.

Every concretion formed in any part of the body is called a calculus or ſtone by medical writers. There are two kinds of muſcular calculi or concretions which originate in the midſt of the fleſhy fibres. The one are merely oſſifications of tendinous fibres, which take place in old animals, at the time when the extremities of tendons and the ſides of veſſels themſelves are oſſified. It is an abuſe of terms to call theſe calculi. The other kind of muſcular concretions of a granular, angular, or irregular figure, which are met with, though indeed rarely, in the internal parts of the muſcles themſelves, between the fleſhy maſſes, and which are moſt frequently found after long continuance of gout: theſe have not been analyſed. It is probable that they are of the ſame nature as thoſe found in gouty articulations, and analogous to the ſolid matter of bones. Fourcroy was not able to procure a ſingle muſcular calculus during the courſe of twelve years enquiry.

Anatomiſts have frequently found ſolid concretions in the human pancreas. They have not been analyſed. Nothing is more common than to find ſeveral ſmall ſtones in the pineal gland of the human head. This fact is generally known to anatomiſts; but either on account of their ſmallneſs, and the difficulty of procuring a ſufficient number, or the little attention which has been hitherto paid to the utility of chemiſtry in the philoſophy of animal bodies, no examination has yet been made of this intereſting object.

It is not uncommon for old perſons who have been long ſubject to arthritic affections, to expectorate, by coughing, ſmall irregular calculi, which Mr. Roering affirms to be of the ſame nature as the baſis of bones; that is to ſay, phoſphorated lime.

Stones are formed in the kidneys, which are the natural filter of the urine. The human ſpecies is very ſubject to this diſorder. When the reinal calculi are ſmall, they are carried along with the urine through the urethers, and evacuated under the name of gravel; but when they are retained they produce more ſerious evils, for which medicine at preſent poſſeſſes no remedy. This concretion in man is of the ſame nature as the ſtone of the bladder, as Fourcroy found by examination.

The ſingular properties of the urine of the horſe are well known. It is much more charged with matter that ſubſides than urine of men, and hence it becomes turbid at the very inſtant of its emiſſion. The powder which falls down from the urine of the horſe is for the moſt part chalk, as Fourcroy aſſerts, whereas that which is precipitated from human urine, eſpecially at the end of attacks of illneſs, is the acid of the ſtone of the bladder. On examination of the reinal calculus of a horſe, its component parts were found to correſpond with thoſe of the urine of the animal.

The ſalivary calculi are not rare, particularly in the porotid and ſublingual glands. Medical writers abound with obſervations relative to theſe concretions, but nothing chemical has been done reſpecting them. They have been ſuppoſed to be of the ſame nature as the tartar of the teeth, which Fourcroy has aſcertained to be phoſphorated lime.

Different ſpecies of calculi are found in the ſtomach of man, particularly biliary concretions, ſtony and ſtratified concretions, and balls of hair or fibres agglutinated by a concreſcible lymph. Many facts of this nature are extant, but none of the narratives exhibit materials to aſcertain the intimate nature of theſe concretions.

The property of forming calculi is obſerved likewiſe in vegetables. Several botaniſts have deſcribed theſe vegetable concretions, particularly in the cocoa, the palm, &c. There are ſeveral in the collection of Juſſieu. Fourcroy ſaw ſome which were round, white, poliſhed like ivory, and apparently very hard. He could not aſcertain their nature, on account of their ſcarcity and dearneſs. They are called vegetable bezoar, and the credulity which accompanies all the prejudices of medicine has extolled them as very powerful remedies.

It is well known that ſeveral fruits, more eſpecially pears, are very ſubject to contain a quantity ſometimes conſiderable of granulated, irregular, hard concretions which are known by the name of ſtones. Mr. Vauquelin has made a number of experiments upon theſe, which prove that they are of the ſame nature as wood.

STORAX. The moſt fragrant of the ſolid reſins, and indeed of all the known vegetable ſubſtances, is ſtorax or ſtyrax, obtained from a tree of the ſame name, ſaid to grow moſt plentifully in Syria, Cilicia, and Pamphilia. America likewiſe produces ſtorax-trees, but not that particular ſpecies which affords the officinal reſin. The true ſtorax-tree has leaves like thoſe of the quince, and hence is named by Caſpar Bauhin and Tournefort, Styrax folio mali cotonei: its flowers are white, in ſhape ſomewhat like a funnel, divided into ſeveral ſegments about the edges: the fruit is about the ſize of a hazel-nut.

The fine ſtorax, called red ſtorax, or ſtorax in the tear, is the pure native juice, flowing from inciſions made in the trunk of the tree. This is very rarely to be met with. The common ſtorax is ſuppoſed to be in part an artificial compoſition, mixed with a conſiderable portion of the genuine reſin. Of the production however of this concrete we have no ſatisfactory account. That it is not an artificial compoſition may be judged from hence; that notwithſtanding its large admixture of ſaw-duſt, it is more fragrant than the pure ſtorax in the tear, and its fragrance is exactly of the ſame kind. Some reſinous bodies indeed diſcover a greater degree both of ſmell and taſte, when diluted with other ſubſtances of themſelves inodorous and inſipid, than in their pure ſtate: but the pure reſin extracted from common ſtorax by ſpirit of wine, is ſtill more fragrant than the ſtorax itſelf, or the reſin prepared by the ſame means from ſtorax in the tear.

It ſeems probable, that the pure ſtorax is the juice which concretes upon the tree, and which has loſt in the drying its more ſubtle odoriferous parts; and that the common ſtorax is the juice received immediately in veſſels, and mixed with ſaw-duſt enough to thicken it; the ſhops requiring under the name of ſtorax a ſolid or conſiſtent maſs, and evaporation being found to diſſipate its fragrance. Neumann obſerves, that he cannot conceive for what other purpoſe the woody matter could be added; for it is too eaſily diſtinguiſhable to have been intended as an impoſition.

The ſtorax-tree is ſaid to grow ſpontaneouſly, not only in the eaſtern countries, but in Italy; whether it yields any reſin there, we have no account. It ſcarcely bears the winters of our climate without ſhelter.

The common ſtorax was formerly brought to us incloſed in reeds or canes, whence its name ſtyrax calamita: at preſent we meet with it in large cakes or loaves, of a reddiſh brown colour, ſoftiſh, and as it were unctuous to the touch, yet brittle and friable, and of an extremely pleaſant ſweet ſmell.

Out of an ounce of common ſtorax, rectified ſpirit of wine diſſolved ſix drams; from the reſiduum, water extracted half a dram of gummy matter; the reſt was almoſt mere ſaw-duſt. Another ounce of the ſame ſtorax, treated with water at firſt, gave two drams of extract; after which it yielded with ſpirit four drams of reſin, the ſaw-duſt remaining as before.

Pure ſpirit elevates in diſtillation very little of the ſmell of the ſtorax: the diſtilled water is notably impregnated with its fine flavour, but no ſeparable oil is obtained. To determine this laſt point more fully, Neumann diſtilled eight ounces of ſtorax with ſixteen ounces of water in a glaſs retort. No appearance of oil could be perceived till the water was almoſt all drawn off, and the remaining ſtorax began to grow dry and ſcorched: then aroſe a fine ſubtle oil, weighing two ſcruples, together with nine drams of an empyreumatic liquor: preſently ſucceeded two drams and a ſcruple of thick butyraceous oil, and afterwards two ounces one dram of an empyreumatic oil, which had nothing of the ſmell of the ſtorax, along with five drams of an acid ſpirit: the reſiduum weighed two ounces and ſeven drams. The butyraceous oil being waſhed with warm water, and the water ſet by in a cold place, a ſmall portion of ſaline matter ſeparated, ſimilar in appearance to the flowers of benzoin.

Though rectified ſpirit diſtilled from ſtorax brings over little or nothing of its ſmell; we may neverthelеſs obtain a ſpirit pretty ſtrongly impregnated both with the ſmell and taſte of the ſtorax, by previouſly mixing the reſin with twice its weight of ſalt of tartar, and drawing over a rectified ſpirit of wine from this mixture. The ſtrongeſt and moſt fragrant principle, ſeparable from ſtorax, is the ſubtile, ſlightly empyreumatic oil, which ariſes firſt in the diſtillation of it.

In the ſhops, we meet with a fluid reſinous ſubſtance, called ſtyrax liquida. This is ſaid by ſome to be extracted by expreſſion from the bark of the ſtorax-tree; by ſome from the leaves, or the leaves and bark together; and by others, to be a compoſition of turpentine, oil, wine, and a little ſolid ſtorax. This laſt account is the moſt probable. Neumann informs us, there was a perſon in his neighbourhood (Berlin) who prepared ſome hundred weights every year, and was ſaid to employ chiefly common reſin.

Lewis in a note on this paſſage obſerves, that the genuine liquid ſtorax is obtained not from the tree which yields the ſolid ſtorax, but from one of a different genus, though uſually called by the ſame name. That which yields the ſolid is diſtinguiſhed by the epithet quince-leaved, and that which yields the liquid by that of maple-leaved-ſtorax.

The maple-leaved ſtorax-tree is a native of Virginia, Mexico, and ſome other parts of America, and is eaſily naturalized to our own climate. A reſinous juice approaching in fragrance to ſtorax, exudes upon the ſurface of the leaves, and may be extracted more perfectly by ſpirit of wine: the proceſs by which the juice is procured abroad has not been tried with the trees raiſed here.

Liquid ſtorax and liquid amber are ſaid to be both obtained from this one tree, the firſt by boiling the bark or branches in water, the latter by making inciſions in the trunk. Mr. Petiver gives an account, in the Philoſophical Tranſactions, of the preparation of liquid ſtorax, as practiſed in the iſland Cobros in the Red-Sea, from a tree (which probably is no other than this) called by the Turks and Perſians, Roſa Millos. The bark is annually cleared off, and boiled in ſea water to the conſiſtence of bird-lime. The reſinous matter, which floats upon the ſurface, and contains a conſiderable portion of the ſubſtance of the bark, is taken off, liquefied again in boiling water, and paſſed through a ſtrainer. The purer part which paſſes through, and the more impure which remains on the ſtrainer, are both ſent to Mocca, from whence they are ſometimes, but very rarely, brought to us. The firſt is of the conſiſtence of honey, tenacious like turpentine, of a browniſh colour, an acrid aromatic unctuous taſte, and a ſmell approaching to that of ſolid ſtorax, but ſo ſtrong as to be diſagreeable. The impure ſort is full of woody matter, and much weaker in ſmell.

The liquid amber, or juice which iſſues from inciſions in the trunk, is at firſt of the conſiſtence of thin turpentine, but by long keeping grows hard and brittle. It is of a yellow colour, inclining to red, of a hot aromatic taſte, and a fragrant ſmell, not unlike that of ſtorax heightened with a little ambergris. It was formerly much uſed as a perfume, but is at preſent ſcarcely known in the ſhops.

Four drams of liquid ſtorax yielded, with rectified ſpirit of wine, three drams and one ſcruple of reſinous extract; from the remaining two ſcruples, water took up only a few grains: the diſtilled ſpirit ſmelt a little of the reſin. In diſtillation with water, an eſſential oil aroſe, ſimilar in flavour to oil of turpentine, or the oleum pini. By diſtillation in a ſtronger fire, inſtead of a clear empyreumatic oil, what came over was almoſt mere pitch. Theſe experiments are a ſufficient proof that the common liquid ſtorax is an artificial compound.

STRONTIONITE. In the ſecond part of the Philoſophical Tranſactions for 1794, there is an account of a mineral ſubſtance thus denominated from the place Strontion in Scotland, where it is found in granite rocks, accompanied by galena and witherite, by which laſt name, I ſuppoſe, Mr. Schmeiſſer, the author of the analyſis, means the native aerated ponderous earth.

In all the ſpecimens this author had ſeen, he could not diſcover any regular cryſtallized figure. The ſpecimen which he ſubmitted to experiment was in ſolid maſſes, apparently compoſed of long fibres, cloſely adhering together and diſpoſed in radiations; its colour was an aſparagus green, deeper towards the centre of the maſs; when broken, the ſurface was a little ſhining in certain directions, the fragments rather bar-like, and ſomewhat brittle.

Some ſpecimens exhibit only light ſhades of this colour, and appear to be compoſed of long thin bars, which are often ſeparated from each other towards the extremity.

The ſpecimen examined was ſemi-tranſparent, but the moſt of it rather inclining to opake. A hard knife ſcratched it, but it could not be ſcraped. Its ſpecific gravity was 3,586 at 60° of temperature.

The firſt experiments which pointed out a diſtinction between the baſis of this ſtone and the ponderous earth of Scheele, were made by Dr. Crawford's deſire, by his aſſiſtant Mr. Cruikſhank, and were afterwards repeated by himſelf. The account of theſe is inſerted in the ſecond volume of the Medical Communications, by reference to which Mr. Schmeiſſer very properly does juſtice to the original diſcoverers.

Mr. S. found, 1. that the powder of ſtrontionite was not acted on by boiling water, 2. nor by the vitriolic acid; 3. but the nitrous and marine acids ſeverally and entirely diſſolved it with ſtrong efferveſcence: the elaſtic fluid which eſcaped, was pure fixed air. 4. Diluted vitriolic acid, added to the diluted nitrous and marine ſolutions, threw down a white precipitate. 5. Before the blow pipe, a piece of the ſtrontionite did not crackle, nor ſplit aſunder, nor did it melt even when expoſed to white heat; but it diſcovered a very bright phoſphoreſcent light, became more brittle, loſt its greeniſh caſt, and then was partly ſoluble in water. A long continuance of the white heat deprived it of very little of its weight, and it ſtill efferveſced with acids. 6. With borax and with ſoda, it melted with ebullition, but neither a blue nor a green colour was exhibited by fuſion with the former. 7. Fluid volatile alkali did not extract any blue colour from the powdered ſubſtance, nor when added to the acid ſolutions. The ſolutions in the marine and nitrous acids were colourleſs. A piece of paper dipped in the nitrous ſolution, burned with a red flame. 8. The Pruſſian alkali added to a ſaturated ſolution threw down a very ſlight quantity of blue precipitate. 9. Acid of ſugar added to the diluted ſolution afforded a very ſlight precipitate. 10. The remaining liquid of the foregoing experiments was mixed with vitriolic acid, until no more precipitate took place; after which the remaining filtered liquor afforded no earth, when purified potaſh was added to ſaturation. 11. The ſaturated nitrous ſolution afforded cryſtals by evaporation, which were permanent in the air, and exhibited triangular and ſexangular plates. 11. The ſaturated marine ſolution exhibited on evaporation long ſix-ſided priſms, which have the broad alternating with the narrow ſides, and terminate in obtuſe trihedral pyramids. This was obſerved by Dr. Crawford, who alſo found that the ſalt formed of the ſubſtance with acids diſſolved in water, produced five times more cold than the ſalt from the barytes in the ſame acid; that the ſalt formed by marine acid and this ſubſtance, was much more ſoluble in warm water than in cold, whilſt the muriat of barytes is nearly as ſoluble in cold as in warm water; that one ounce of diſtilled water diſſolves three times as much of the muriat of ſtrontionite as of the muriat of barytes, which makes a diſtinction between the baſis of this ſubſtance and the barytes. 12. Nitrous acid added to the marine ſolution of ſtrontionite occaſioned a decompoſition. 13. The earth was procured in a diſtinct ſtate by ſolution in marine acid, precipitation by diluted vitriolic acid, ſubſequent drying, and decompoſition by means of heat, with purified potaſh, waſhing with water, and calcination. The quantity of fixed air contained in this earth was then proportionally aſcertained by ſolution in acid. Mr. Schmeiſſer then found, that a hundred grains of ſpecific vitriolic acid, by which I ſuppoſe he means the particular acid he made uſe of, required 133 grains of the pure earth for ſaturation, but that 130 grains of pure ponderous earth were required for the ſame purpoſe; that a hundred grains of nitrous acid required 94 grains of this earth, but 120 grains of the ponderous earth, for its ſaturation; and that 100 grains of marine acid required 56 of this earth, but 96 of the ponderous.

Hence Mr. Schmeiſſer concludes, 1. That the native mineral contained no ſaline matter. 2. That it contained fixed air; and 3. An earth ſimilar to the ponderous earth in its habitudes with the vitriolic acid. 4. No water of cryſtallization. 5. No cobalt nor copper. 6. A ſmall portion of iron. 7. Some calcareous earth.

8. No argillaceous nor magneſian earth; and 9. That the earthy baſis is of a different nature from ponderous earth.

In order to aſcertain the quantity or proportion of component parts of this ſubſtance, he diſſolved 100 grains in acid, which yielded 30 grains of fixed air. Half a grain of calcareous earth was precipitated by acid of ſugar, and the remaining ſolution yielded by decompoſition 68 grains of the peculiar earth, which may be called ſtrontion earth. The remaining weight may be accounted for from the ſubſtance which gives it the colour, which from comparative experiments Mr. Schmeiſſer ſuppoſes to be phoſphorated iron and manganeſe.

The ſubſtance with which it was accompanied, was cryſtallized in ſix-ſided priſms, with pyramids, colourleſs, ſemi-tranſparent, rather opake towards the baſis, and leſs hard than the other ſubſtance. By analyſis it was found to contain ſeventy grains of ponderous earth, fifteen grains of fixed air, and twelve of calcareous earth.

SUBLIMATE, CORROSIVE. There are ſeveral ways of preparing corroſive ſublimate. The moſt common way is, by mixing equal parts of dried mercurial nitre, decrepitated common ſalt, and calcined or white martial vitriol; putting this mixture into a matraſs, of which two thirds muſt remain empty; immerſing the mixture into a ſand bath, and heating it gradually till its bottom is made red hot. The vitriolic diſengages the marine a cidfrom the ſoda: the ſoda again ſeparates the nitrous acid from the mercury, which has robbed it of part of its vital air; after that the marine acid combines with the calx of mercury, and forms corroſive mercurial ſublimate, which riſes in flat pointed cryſtals, that fix on the upper part of the matraſs. The nitrous acid is diſperſed in nitrous gas; the reſidue is reddiſh or brown, and contains calx of iron and common Glauber's ſalt, formed by the combination of the vitriolic acid with the baſe of the marine ſalt. In Holland, this ſalt is prepared in the large way by triturating together equal parts of mercury, common ſalt and vitriol of iron, and expoſing the mixture to a ſtrong heat. In this way of preparing corroſive ſublimate, the vitriolic acid, diſengaged by heat from the vitriol of iron, appears to convert the ſimple into aerated muriatic acid; for no other but this laſt acid could diſſolve all the mercury employed on the occaſion. Corroſive mercurial ſublimate may be likewiſe obtained by ſubliming a mixture of vitriol of iron, common ſalt, and mercurial precipitate, by fixed alkali, or any other kind of mercurial calx.

Boulduc has given a very good proceſs for preparing corroſive mercurial ſublimate: but Speilman remarks, that it was before ſuggeſted by Kunckel in his Chemical Laboratory. It conſiſts in heating in a matraſs equal quantities of vitriolic ſalt of mercury, and decrepitated common ſalt. Corroſive ſublimate is volatilized, and what remains is only Glauber's ſalt. This mode of operation affords a very pure corroſive ſublimate; whereas that which we obtain in commerce, and even that which is prepared in the ſmall way with vitriol of iron, always contains ſome mixture of iron. Boulduc's proceſs is both eaſier and leſs expenſive. It likewiſe proves, that the vitriolic acid poſſeſſes the property of aerating the muratic acid in theſe circumſtances. M. Monnet informs us, that he obtained this ſalt alſo, by treating in a retort very dry common ſalt with mercurial calx precipitated from the nitrous ſolution of mercury by fixed alkali. In all theſe proceſſes for preparing corroſive mercurial ſublimate, the operator ſhould beware of breaking the veſſel containing the ſublimate till it be perfectly cool, leſt he ſuffer from the vapours of the ſalt. Laſtly, there is yet another and more expeditious way of preparing corroſive mercurial ſublimate: it conſiſts in pouring aerated muriatic acid into a ſolution of nitrated mercury, and evaporating the mixture ſlowly: when the nitrous acid is diſengaged, the liquor affords, by cooling, cryſtals of the corroſive mercurial ſalt. There is reaſon to think, that when Scheele's aerated muriatic acid becomes better known, apothecaries will prepare corroſive mercurial ſublimate, either by this laſt proceſs or by ſimple ſolution.

Corroſive mercurial ſublimate is a neutral ſaline ſubſtance, which well merits the attention of chemiſts and phyſicians. It poſſeſſes a number of valuable properties, which Fourcroy has enumerated. It has a very cauſtic taſte. When but the ſmalleſt quantity touches the tongue, it leaves for a long time after a ſtiptic and metallic impreſſion, which is very diſagreeable. This impreſſion extends even to the larynx, cloſing it ſpaſmodically; and the effect remains long, particularly on perſons of very delicate nerves. This ſalt acts in a ſtill more ſenſible manner on the coats of the ſtomach and the viſcera. When ſuffered to act upon them for ſome time, it corrodes them ſo as to deſtroy their ſubſtance: it is of conſequence one of the ſtrongeſt poiſons known. The cauſticity of corroſive mercurial ſublimate appears to depend on the ſtate in which the mercury exiſts in the ſalt, as has been very ingeniouſly explained by Macquer. It cannot, as ſome authors have imagined, be aſcribed to the muriatic acid; for the quantity of the mercury is more than three times as much as that of the acid. Accordingly, it has been obſerved by Rouelle, that this ſalt communicates rather a green than a red colour to ſyrup of violets. The taſte too of corroſive mercurial ſublimate is much ſtronger than that of the muriatic acid. A perſon may take a dram of muriatic acid diluted in water, without ſuffering any harm: whereas a few grains of mercurial muriate taken in the ſame quantity of water are a certain poiſon. Bucquet thought this exceſſive ſapidity to depend on the combination of the two bodies which compoſe this ſalt. One of his ſtrongeſt proofs was drawn from that law of the affinity of compoſition by which it is eſtabliſhed, that compounds poſſeſs new properties entirely different from thoſe of the bodies of which they are compounded.

Corroſive mercurial ſublimate ſuffers no ſenſible alteration from light. Heat volatilizes and half vitrifies it. When expoſed to a ſtrong heat in the open air, it is diſſipated in a white ſmoke, the effects of which are very energetic, and very noxious to the animal œconomy. When heated ſlowly and by degrees, it is ſublimed in a regular cryſtalline form. Its cryſtals are priſms, ſo compreſſed, that it is impoſſible to determine the number of their faces. They terminate in very acute points; and have been with good reaſon compared to the blades of poniards thrown very confuſedly together. Fire does not decompoſe this ſalt; it ſuffers no alteration from air. It diſſolves in nineteen parts of water, and cryſtallizes by evaporation into flat priſms, very acute at their extremities, reſembling thoſe obtained by ſublimation. The ſpontaneous evaporation of its ſolution afforded both Fourcroy and M. Bucquet ſeveral times oblique-angled parallelopipeds, with their extremities truncated ſlopewiſe. M. Thouvenel has obtained that ſalt cryſtallized in hexahedral priſms a little compreſſed.

Barytes, magneſia, and lime decompoſe corroſive mercurial muriate, cauſing it to yield a precipitate of calx of mercury. The phagedenic water uſed by ſurgeons as a corroſive, is prepared by adding half a dram of this ſalt in powder to a pound of lime-water; a yellow precipitate is formed, which renders the liquor turbid, and it is employed before the precipitate ſubſides. The fixed alkalis ſeparate from corroſive mercurial ſublimate an orange-coloured calx, which, when ſuffered to ſettle for ſome time, acquires a deeper colour. Volatile alkali cauſes this ſalt to yield a white precipitate, which however ſoon aſſumes a ſlate colour.

The acids of the alkaline neutral ſalts produce no alteration on corroſive mercurial ſublimate.

This ſalt contracts an intimate union with ſal ammoniac; but neither of them is decompoſed. Either by ſublimation, or by cryſtallization, it forms with it a very ſingular ſaline compound, which the alchemiſts valued highly, and called alembroth ſalt, ſalt of art, ſalt of wiſdom, &c. The ſal ammoniac renders the corroſive ſublimate very ſoluble; for, according to Baumé, three ounces of water, containing nine drams of the former ſalt, diſſolve five ounces of the latter. This laſt ſolution is effected by the help of heat; and when it cools, the ſalt ſubſides into a maſs. With this ſalt a preparation is made up which is called white precipitate. It is prepared by caſting into a ſolution of a pound of ſal ammoniac an equal quantity of corroſive mercurial ſublimate in powder. When this ſalt is fully diſſolved, a ſolution of mild vegetable alkali is poured into the mixture, and produces a white precipitate: this precipitate is waſhed, formed into little balls, and dried in the air. In this operation the pot-aſh diſengages the volatile alkali; which in its turn precipitates the mercury in a white calx. This precipitate becomes yellow when expoſed to heat, or even to light.

Corroſive mercurial ſublimate is altered by inflammable air. Sulphur produces no change on it, but liver of ſulphur decompoſes it as well as the other ſolutions of mercury: the immediate product of this decompoſition is a black precipitate, which reſults from the combination of the ſulphur with the mercury. Moſt of the ſemi-metals are capable of decompoſing this ſalt: and each of theſe inſtances of decompoſition is attended with peculiar phænomena.

When two parts of corroſive mercurial ſublimate with one of arſenic are diſtilled by a moderate heat, there paſſes into the receiver a matter of the conſiſtency of oil, and tranſparent, of which one part is very ſoon condenſed into a kind of white jelly, improperly called corroſive oil, or butter of arſenic. If the heat be continued after this product has paſſed off, running mercury is obtained; and by this proceſs we may attain an accurate knowledge of the principles of corroſive mercurial ſublimate. This marine combination of arſenic does not appear to be ſuſceptible of cryſtallization; it melts by a moderate heat, and its taſte is ſo cauſtic that it inſtantaneouſly deſtroys our organs. It diſſolves in water, by which it is partly decompoſed: we are ignorant of its other properties. It cannot be obtained with calx of arſenic; becauſe when that ſemimetal is already ſaturated with vital air, it cannot diſengage mercury from its combination with the muriatic acid, by abſorbing that principle.

The effects of nickel, cobalt, and manganeſe, on corroſive mercurial ſublimate, have not yet been examined. As to biſmuth, antimony, and zinc, thoſe three ſemi-metals decompoſe this ſalt very readily. By diſtilling two parts of corroſive mercurial ſublimate with one of biſmuth, we obtain a thick fluid ſubſtance, which congeals into a kind of greaſy maſs that melts on being expoſed to heat, and yields a precipitate when plentifully waſhed: in a word, this compound is ſolid marine ſalt of biſmuth. Doli, quoted by Fourcroy, who has given an account of this proceſs in the Hiſtory of the Academy for the year 1713, tells us, that when this butter of biſmuth is ſeveral times ſublimed, there remains

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in the veſſel a powder coloured like oriental pearls, very ſoft and gluey: he propoſes the uſe of this powder in painting.

When twelve ounces of antimony are completely mixed with two pounds of corroſive mercurial ſublimate, the mixture gives out heat; a circumſtance which proves that theſe two bodies act rapidly on each other. On diſtilling this mixture by a moderate heat, we obtain a thick liquor which is fixed in the receiver, and often even in the neck of the retort, into a white maſs called butter of antimony. The quantity of this ſublimated marine combination of antimony is commonly ſixteen ounces and a few drams. The reſidue conſiſts of mercury and a gray powder of antimony, which ſwims on the ſurface of the metallic fluid. On continuing the diſtillation after the butter of antimony has paſſed into the receiver, and uſing a new receiver, we obtain running mercury; but it is contaminated with a little of the butter of antimony, as that ſubſtance cannot be entirely taken away from the neck of the retort. Mr. Baumé, who has given a good account of this operation, ſays, that by this proceſs twenty-two ounces of running mercury may be obtained, one ounce of antimony in powder mixed with mercury, and ſix drams twenty-four grains of antimony fuſed in the retort. The antimony is partly calcined: it affords a red and partly white calx which is ſublimed. In this inſtance, the antimony is calcined by the vital air ſeparated from the mercurial calx, and combines with the muriatic acid to form butter of antimony. This decompoſition likewiſe takes place when crude antimony is employed. By diſtilling one part of that mineral in powder, with two parts of corroſive mercurial ſublimate, ſublimated muriate of antimony is obtained; but the reſidue, inſtead of containing running mercury, is a combination of mercury with ſulphur. That combination may be ſublimed by a very ſtrong heat into red needles, which are improperly called cinnabar of antimony.

Sublimed butter of antimony, or the combination of the aerated marine acid with antimony, is not produced unleſs when the ſemi-metal attracts from the mercury the vital air which it contains; as has been already obſerved of arſenic. This compound is in a cryſtalline form. It cryſtallizes into very large parallelopipeds. It is ſo cauſtic that it inſtantly deſtroys our organs, and burns vegetable matters. It is very liable to alteration by the contact of light. It melts with the moſt moderate heat, and becomes fixed by cooling: it is this property which has procured it the name of butter of antimony. It readily loſes its whiteneſs, and becomes coloured. It may be rectified by diſtillation. It attracts the moiſture of the atmoſphere, by which it is again diſſolved into a thick and ſeemingly oleaginous fluid: in water it is diſſolved only in part; for the greateſt portion of it is decompoſed by that fluid. When butter of antimony is caſt into diſtilled water, it immediately gives a very copious precipitate, which is commonly called emetic powder, or powder of algaroth, from the name of an Italian phyſician who uſed it as a medicine. It has likewiſe been improperly called mercury of life. This precipitate is a calx of antimony ſtrongly purgative and emetic, even when given in very ſmall doſes of three grains and a half to the doſe. In order to render it very pure, it muſt be repeatedly waſhed in diſtilled water. It differs in poſſeſſing theſe properties from the other calces of this ſemi metal, which are far from acting in ſo energetic a manner on the animal œconomy. A portion of this calx is diſſolved in the water, in which butter of antimony is waſhed, by means of the acid which mixes with the fluid. We have an opportunity of obſerving this fact on pouring a little alkali into that liquor:

quor: a white precipitate is produced in conſiderable abundance; and butter of antimony therefore appears to owe its property of being decompoſable in water to its containing an exceſs of this calx; and its forming into a ſolid maſs may be attributed to the ſame cauſe. Sublimed butter of antimony diſſolves with heat and effervеſcence in the nitrous acid. From that ſolution there is diſengaged a large quantity of nitrous air, which excites a conſiderable motion in the mixture; the muriate of antimony diſappears, and the liquor appears of a reddiſh yellow colour. This is a ſolution of calx of antimony in the nitro-muriatic acid, or aqua regia. It very ſoon depoſits the calx of antimony in the form of a powder, and even of a white magma.

If the ſolution of butter of antimony by the nitrous acid be evaporated to dryneſs as ſoon as made, it yields a very white calx: this is diluted with a quantity of the ſame acid equal to its own weight, and again evaporated: the powder is yet a third time mixed with the ſame quantity of nitrous acid, and evaporated to dryneſs: it is then treated in a crucible, which is kept red-hot for about half an hour, and after that ſuffered to cool. The calx now taken out of the crucible is white above, and roſe-coloured on the under part. The two portions are then mixed, and form by their mixture what is called bezoar-mineral. Macquer conſiders this medicine as a perfect calx of antimony, and thinks it to be the ſame with diaphoretic antimony. Lemery, however, who has given an accurate deſcription of this preparation, adviſes us to calcine it till it have ſcarce any acidity; but wiſhing it to retain ſome acid, which muſt certainly change the properties of the calx of antimony.

Corroſive mercurial ſublimate is decompoſed by fire, as has been aſſerted by Pott, and as Fourcroy found by repeated experiments. If you diſtil in a glaſs retort a mixture conſiſting of two parts of this ſalt with one of zinc in filings, or coarſe powder, a white and ſolid ſalt aſcends from the mixture, and is cryſtallized in ſmall needles joined together, in a form reſembling the little bundles of which ſtalactites conſiſt. This marine combination of zinc emits a thin ſmoke when it is taken out of the receiver: it melts by a moderate heat; is coloured by inflammable vapours; and laſtly, is partly decompoſed in water like ſublimated butter of antimony.

SUBLIMATE RED. See Precipitate Red. If a greater heat be applied to red precipitate than was required to produce the red colour, it becomes decompoſed, and the products are vital air and running mercury. But if the application of the heat be ſudden, the red compound is volatilized for the moſt part without decompoſition. This has been called red ſublimate; but it is very ſeldom prepared or uſed.

SUBLIMATE SWEET, or mild Mercurial-Calomel of the London College. The moſt ſingular property which corroſive mercurial ſublimate exhibits in regard to the alterations which it ſuffers from metallic ſubſtances, as well as the moſt important property which it poſſeſſes, is its power of combining with running mercury. When ſaturated with that metallic fluid, it loſes moſt of its properties, particularly its taſte and ſolubility. The old way of producing this combination was, by triturating in a glaſs mortar corroſive mercurial ſublimate with running mercury, adding the mercury by degrees till it refuſed to unite with the mercurial ſublimate. Lemery and Baumé have obſerved, that the ſalt takes up a quantity of mercury equal to about three-fourths of its own weight. The mixture was then put into ſmall phials, two-thirds of each of them being left empty, and ſublimated three times ſucceſſively. Care was taken to ſeparate at each time a white powder, which is found above the ſublimated matter, and is very corroſive. This product is called ſweet ſublimate, mercurius dulcis, or aquila alba. Its inſipidity, its cryſtalline form, and its being almoſt totally inſoluble, diſtinguiſh it from corroſive mercurial ſublimate. The cryſtals which it affords by ſlow ſublimation are tetrahedral priſms terminating in four-ſided priſms. We often find among them two very long tetrahedral pyramids, joined at the baſe, and forming very acute octohedrons.

The proceſs for preparing ſweet mercury here deſcribed is attended with ſeveral inconveniences. To triturate corroſive mercurial ſublimate with running mercury till the mercury be entirely confounded with the mercurial ſalt, is a very tedious and a very difficult taſk. A very minute acrid duſt ariſes from the mixture while it is triturated; and the operator muſt bind a cloth over his mouth and noſe to ſecure himſelf againſt the dangerous effects of that duſt. The mercury is never entirely incorporated with the mercurial ſublimate; and the ſublimation is very ſlow. Baumé adviſes to pour a little water on the matters as they are triturated. That fluid aſſiſts the trituration, and hinders the ſaline duſt from riſing. He likewiſe employs levigation, which contributes greatly to make the mercury incorporate with the ſalt. Laſtly, to make ſure of obtaining mild mercurial ſublimate, without the leaſt mixture of corroſive, Zwelfer, Cartheuſer and Baumé propoſe to pour on mild mercurial ſublimate, after it has been once ſublimated, a quantity of hot water, to diſſolve the corroſive ſublimate, and then dry the ſalt, which is after this found to be much milder than before. Cornette, to hinder the volatilization of the corroſive mercurial ſublimate triturated with the mercury, propoſes to make uſe of nitrate of mercury precipitated by ammoniac, which unites with corroſive mercurial ſublimate much more readily than running mercury. But as this calx is not ſo pure as mercury, we cannot depend ſo much on the virtues of the preparation into which it enters. Bailleau, an apothecary in Paris, has given the Royal Society of Medicine a proceſs for preparing mild mercurial ſublimate, without being expoſed to any of thoſe accidents which render the preparation of it in the common way ſo very dangerous. This proceſs conſiſts in forming a paſte with corroſive mercurial ſublimate and water, and triturating it with running mercury. Half an hour's trituration is here ſufficient; becauſe the water contributes to confound the two ſubſtances together. The proceſs ends with digeſting the mixture on a ſand-bath by a moderate heat; the matter changes its original gray colour for white, and forms a very mild mercurial ſublimate, which needs only to be ſublimed in order that it may be perfectly pure.

Baumé has made ſeveral experiments on mild mercurial ſublimate. He has ſhewn that it cannot receive an additional quantity of mercury; and that it cannot exiſt in a middle ſtate, between the corroſive and the mild mercurial ſublimate. That is to ſay, where a ſmaller portion of mercury is mixed with the corroſive mercurial ſublimate, than is requiſite to make it paſs into the ſtate of mild mercurial ſublimate, a portion of this latter ſalt is formed, in proportion to the quantity of the mercury, and the exceſs of the corroſive ſublimate; and the reſt of the corroſive mercurial ſublimate is volatilized without ſuffering any alteration of its properties. Theſe two compounds are ſeparable by hot water.

From the reſearches of the ſame chemiſt we learn further, that it is poſſible to change the mild into corroſive mercurial ſublimate, by ſublimating it with decrepitated marine ſalt and white calcined vitriol of iron. In this operation the muriatic acid being diſengaged, and aerated by the ſulphuric acid, unites with the mercurial calx of the mild mercury, and converts it into corroſive ſublimate.

limate. Baumé is convinced that mild mercurial ſublimate differs greatly from the corroſive, as it cannot unite with ſal ammoniac like the corroſive mercurial ſublimate in the formation of alembroth ſalt, or ammoniaco-mercurial muriate. It is even from the conſideration of its poſſeſſing this property, that he adviſes to waſh mild mercurial ſublimate with water impregnated with a little ſal ammoniac, to carry off all the corroſive mercurial ſublimate which renders that ſalt ſo very ſoluble. Laſtly, he has diſcovered that at each ſublimation mild mercurial ſublimate loſes a part of its mercury, and affords of conſequence a certain quantity of corroſive mercurial ſublimate; ſo that by repeated ſublimation mild mercurial ſublimate may be entirely changed into corroſive. From this laſt fact it follows, that the medicine known by the name of mercurial panacea, which conſiſts of mild mercurial ſublimate nine times ſublimed, is ſo far from being rendered milder by being ſo often ſublimed, as moſt chemiſts and phyſicians think, that at the end of the proceſs it differs in no reſpect from what it was at firſt. A circumſtance attending the operation may be conſidered as a farther proof of this aſſertion; at each ſublimation a ſmall quantity of white powder which riſes is firſt taken off, which powder is nothing but corroſive mercurial ſublimate. It is to be obſerved, that there remains in the phials a reddiſh powder, when mild mercurial ſublimate is prepared. It is calx of iron produced from the vitriol of iron, which is employed in preparing the common corroſive mercurial ſublimate. Part of that calx aſcends with the ſalt in its ſublimation; nay, the mercurial ſalt in vapour is often found to carry up with it even pieces of glaſs.

Late experiments on the aerated muriatic acid render the theory of the formation of mild mercurial ſublimate much more clear and intelligible than it formerly was. It has been proved that corroſive mercurial ſublimate is a compound of aerated muriatic acid with calx of mercury, and that mild mercurial ſublimate is formed by the common muriatic acid with the ſame metallic calx: or, what amounts to the ſame thing, that in corroſive ſublimate the calx is much more calcined than in the ſublimate. Thus, when running mercury is triturated with corroſive mercurial ſublimate, the mercury ſeizes the exceſs of vital air contained in the marine acid, or in the former mercurial calx; and as a larger quantity of mercurial calx, and that leſs completely calcined, now combines with the ſame quantity of marine acid, the nature of the ſalt is of conſequence altered, and it becomes leſs ſaline, more inſipid, and more inſoluble: in a word, its qualities are weakened in proportion as the quantity of the mercurial calx is increaſed.

SUBLIMATION is a proceſs by which volatile ſubſtances are raiſed by heat, and again condenſed in the ſolid form.

This operation is founded on the ſame principles as diſtillation, and its rules are the ſame, as it is nothing but a dry diſtillation. Therefore all that has been ſaid on the article Distillation is applicable here, eſpecially in thoſe caſes where ſublimation is employed to ſeparate volatile ſubſtances from others which are fixed or leſs volatile.

Sublimation is alſo uſed in other caſes: for inſtance, to combine volatile matters together, as in the operation of the ſublimates of mercury; or to collect ſome volatile ſubſtances, as the acid of borax, ſulphur, and all the preparations called flowers.

The apparatus for ſublimation is very ſimple. A matraſs or ſmall alembic is generally ſufficient for the ſublimation of ſmall quantities of matter. But the veſſels and the method of managing the fire vary according to the nature of the matters which are to be ſublimed, and according to the form which is to be given to the ſublimate.

The beauty of ſome ſublimates conſiſts in their being compoſed of very fine, light parts, ſuch as almoſt all thoſe called flowers; as flowers of ſulphur, of benjamin, and others of this kind. When the matters to be ſublimed are at the ſame time volatile, a high cucurbit, to which is adapted a capital, and even ſeveral capitals placed one upon another, are employed. The ſublimation is performed in a ſand-bath, with only the preciſe degree of heat requiſite to raiſe the ſubſtance which is to be ſublimed, and the capitals are to be guarded as much as poſſible from heat. The height of the cucurbit and of the capitals ſeems well contrived to accompliſh this intention.

When along with the dry matter which is to be collected in theſe ſublimations a certain quantity of ſome liquor is raiſed, as happens in the ſublimation of acid of borax, and in the rectification of volatile concrete alkali, which is a kind of ſublimation, a paſſage and a receiver for theſe liquors muſt be provided. This is conveniently done by uſing the ordinary capital of the alembic, furniſhed with a beak and a receiver.

Some ſublimates are required to be in maſſes as ſolid and compact as their natures allow. Of this number are camphor, ſal ammoniac, and all the ſublimates of mercury. The propereſt veſſels for theſe ſublimations are bottles or matraſſes, which are to be ſunk more or leſs deeply in ſand, according to the volatility and gravity of the matters that are to be ſublimed. In this manner of ſubliming, the ſubſtances having quitted the bottom of the veſſel, adhere to its upper part; and as this part is low and near the fire, they there ſuffer a degree of heat ſufficient to give them a kind of fuſion. The art, therefore, of conducting theſe ſublimations, conſiſts in applying ſuch a degree of heat, or in ſo diſpoſing the ſand (that is, making it cover more or leſs the matraſs), that the heat in the upper part of the matraſs ſhall be ſufficient to make the ſublimate adhere to the glaſs, and to give it ſuch a degree of fuſion as is neceſſary to render it compact; but at the ſame time this heat muſt not be ſo great as to force the ſublimate through the neck of the matraſs, and diſſipate it. Theſe conditions are not eaſily to be attained, eſpecially in great works.

Many ſubſtances may be reduced into flowers, and ſublimed; but which require for this purpoſe a very great heat, with the acceſs of free air, and even the contact of coals, and therefore cannot be ſublimed in cloſe veſſels. Such are moſt ſoots or flowers of metals, and even ſome ſaline ſubſtances. When theſe ſublimates are required, the matters from which they are to be ſeparated muſt be placed among burning coals in open air; and the flowers are collected in the chimney of the furnace in which the operation is performed. The tutty, calamine, or pompholix, collected in the upper part of furnaces in which ores are ſmelted, are ſublimates of this kind.

SUGAR is a conſtituent part of vegetables, exiſting in conſiderable quantities in a number of plants. It is afforded by the maple, the birch, wheat, and Turkey corn. Margraaf obtained it from the roots of beet, red beet, ſkirret, parſneps, and dried grapes. The proceſs of this chemiſt conſiſted in digeſting theſe roots, raſped or finely divided, in alcohol. This fluid diſſolves the ſugar; and leaves the extractive matter untouched, which falls to the bottom.

In Canada the inhabitants extract ſugar from the maple (acer montanum candidum). At the commencement of ſpring they heap ſnow in the evening at the foot of the tree, in which they previouſly make apertures for the paſſage of the returning ſap. Two hundred pounds of this juice afford by evaporation fifteen of a browniſh ſugar. The quantity prepared annually amounts to fifteen thouſand weight.

Dr. Ruſh, in the Tranſactions of the American Philoſophical Society, vol. iii. has given an account at length of the ſugar maple-tree, of which the following is a ſhort abſtract:

The acer ſaccharinum of Linné, or ſugar maple-tree, grows in great quantities in the weſtern counties of all the middle ſtates of the American union. It is as tall as the oak, and from two to three feet in diameter; puts forth a white bloſſom in the ſpring, before any appearance of leaves: its ſmall branches afford ſuſtenance for cattle, and its aſhes afford a large quantity of excellent pot-aſh. Twenty years are required for it to attain its full growth. Tapping does not injure it; but on the contrary it affords more ſyrup, and of a better quality, the oftener it is tapped. A ſingle tree has not only ſurvived, but flouriſhed, after tapping for forty years. Five or ſix pounds of ſugar are uſually afforded by the ſap of one tree; though there are inſtances of the quantity exceeding twenty pounds. The ſugar is ſeparated from the ſap either by freezing, by ſpontaneous evaporation, or by boiling. The latter method is the moſt uſed. Dr. Ruſh deſcribes the proceſs; which is ſimple, and practiſed without any difficulty by the farmers.

From frequent trials of this ſugar, it does not appear to be in any reſpect inferior to that of the Weſt Indies. It is prepared at a time of the year when neither inſect, nor the pollen of plants, exiſts to vitiate it, as is the caſe with common ſugar. From calculations grounded on exiſting facts, it is aſcertained, that America is now capable of producing a ſurplus of one eighth more than its own conſumption; that is, on the whole, about 135,000,000 pounds; which in the country may be valued at fifteen pounds weight for one dollar.

The Indians likewiſe extract ſugar from the pith of the bamboo.

But the ſugar which is ſo univerſally uſed is afforded by the ſugar-cane (arundo ſaccharifera), which is raiſed in our colonies. When this plant is ripe, it is cut down, and cruſhed by paſſing it between iron cylinders, placed perpendicularly, and moved by water or animal ſtrength. The juice which flows out by this ſtrong preſſure is received in a ſhallow trough placed beneath the cylinder. This juice is called in the French ſugar-colonies veſou; and the cane, after having undergone this preſſure, is called begaſſe. The juice is more or leſs ſaccharine, according to the nature of the ſoil on which the cane has grown, and the weather that has predominated during its growth. It is aqueous when the ſoil or the weather has been humid; and in contrary circumſtances it is thick and glutinous.

The juice of the cane is conveyed into boilers, where it is boiled with wood aſhes and lime. It is ſubjected to the ſame operation in three ſeveral boilers, care being taken to remove the ſcum as it riſes. In this ſtate it is called ſyrup; and is again boiled with lime and alum till it is ſufficiently concentrated, when it is poured into a veſſel called the cooler. In this veſſel it is agitated with wooden ſtirrers, which break the cruſt as it forms on the ſurface. It is afterwards poured into caſks, to accelerate its cooling; and while it is ſtill warm, it is conveyed into barrels ſtanding upright over a ciſtern, and pierced through their bottom with ſeveral holes ſtopped with cane. The ſyrup which is not condenſed filters through theſe canes into the ciſtern beneath; and leaves the ſugar in the ſtate called coarſe ſugar, or muſcovado. This ſugar is yellow and fat, and is purified in the iſlands in the following manner: The ſyrup is boiled, and poured into conical earthen veſſels,

veſſels, having a ſmall perforation at the apex, which is kept cloſed. Each cone, reverſed on its apex, is ſupported in another earthen veſſel. The ſyrup is ſtirred together, and then left to cryſtallize. At the end of fifteen or ſixteen hours, the hole in the point of each cone is opened, that the impure ſyrup may run out. The baſe of theſe ſugar loaves is then taken out, and white pulverized ſugar ſubſtituted in its ſtead; which being well preſſed down, the whole is covered with clay, moiſtened with water. This water filters through the maſs, carrying the ſyrup with it which was mixed with the ſugar, but which by this management flows into a pot ſubſtituted in the place of the firſt. This ſecond fluid is called fine ſyrup. Care is taken to moiſten and keep the clay to a proper degree of ſoftneſs, as it becomes dry. The ſugar loaves are afterwards taken out, and dried in a ſtove for eight or ten days; after which they are pulverized, packed, and exported to Europe, where they are ſtill further purified.

The operation of the French ſugar refiners conſiſts in diſſolving the caſſonade, or clayed ſugar, in lime water. Bullocks blood is added, to promote the clarifying; and, when the liquor begins to boil, the heat is diminiſhed, and the ſcum carefully taken off. It is in the next place concentrated by a briſk heat; and, as it boils up, a ſmall quantity of butter is thrown in, to moderate its agitation. When the boiling is ſufficiently effected, the fire is put out; the liquor is poured into moulds, and agitated, to mix the ſyrup together with the grain ſugar already formed. When the whole is cold, the moulds are opened, and the loaves are covered with moiſtened clay, which is renewed from time to time till the ſugar is well cleanſed from its ſyrup. The loaves being then taken out of the moulds, are carried to a ſtove, where they are gradually heated to the fiftieth degree of Reaumur. They remain in this ſtove eight days, after which they are wrapped in blue paper for ſale.

The ſeveral ſyrups, treated by the ſame methods, afford ſugars of inferior qualities; and the laſt portion, which no longer affords any cryſtals, is ſold by the name of melaſſes. The Spaniards uſe this melaſſes in the preparation of ſweet-meats.

A ſolution of ſugar, much leſs concentrated than that we have juſt been ſpeaking of, lets fall by repoſe cryſtals which affect the form of tetrahedral priſms, terminated by dihedral ſummits, and known by the name of ſugar-candy.

The preceding account of the manufacture of ſugar in the colonies is chiefly extracted from Chaptal. The following more ample account is taken from Edwards's Hiſtory of the Weſt Indies, the authority of which is indubitable. For the ſake of conciſeneſs I have availed myſelf of the Abridgment lately publiſhed, which appears to be faithfully done.

The botanical name of the ſugar-cane is arundo ſaccharifera. It is a jointed reed, which terminates in leaves or blades, whoſe edges are finely and ſharply ſerrated. The body of the cane, though brittle, is ſtrong, and, when ripe, is of a fine ſtraw colour inclinable to yellow. It likewiſe contains a ſoft pithy ſubſtance, which is replete with juice of a moſt agreeable taſte. The general diſtance between each joint of the cane, is from one to three inches in length, and from half an inch to an inch in diameter; and the general height, (the flag part being excluded) is from three feet and a half to ſeven feet. In very rich lands, too, the ſtool or root has been known to put forth upwards of one hundred ſuckers or ſhoots.

To bring a plant of this rank and ſucculent nature to perfection, no land can be too rich; and the aſhy loam of St. Chriſtopher's appears to be the beſt ſoil hitherto known, for the production of ſugar of the fineſt quality, and in the largeſt proportion. The next to this in excellence is the ſoil which in Jamaica is called brick-mould. It is a deep, warm, and mellow, hazel earth, which is eaſily worked, and which in the wetteſt ſeaſon ſeldom requires trenching. In a very fine ſeaſon, plant-canes (which are thoſe of the firſt growth) have been known, in this ſoil, to yield two tons and a half of ſugar per acre. The black mould of ſeveral varieties may be reckoned after this. The beſt is the deep black earth of Barbadoes, Antigua, and ſome other of the windward iſlands; but there is a ſpecies of this mould in Jamaica, that is perhaps not in the leaſt inferior to it, which abounds with lime-ſtone and flint, on a ſubſtratum of ſoapy marle. Black mould on clay is more common; and, when properly pulverized and manured, becomes very productive, and may be ſaid to be inexhauſtible. But there are few ſoils that produce a greater return of refined ſugar, than a peculiar ſort of land on the north ſide of Jamaica, and particularly in the pariſh of Trelawney. This land is generally of a red colour, is every where remarkable when firſt turned up for a gloſſy ſurface, and, when wetted, ſtains the fingers like paint. It appears to conſiſt of a native earth or pure loam, with a mixture of clay and ſand; and though deep, it is by no means heavy, and is naturally dry. Hence, as its fertility is deſtroyed when too much expoſed to the burning influence of a tropical ſun, the ſyſtem of huſbandry, where this ſoil abounds, chiefly depends on what is called ratoon canes. Ratoons are the ſuckers that ſpring from the roots or ſtoles of the canes that have been previouſly cut for ſugar, and are generally ripe in twelve months. Plant canes, or canes of the firſt growth, are the immediate produce of the original germs placed in the ground, and require from fifteen to ſeventeen months to bring them to maturity. The firſt yearly returns from their roots are called firſt ratoons, the ſecond year's growth ſecond ratoons, and ſo on, according to their age. The common yielding too of this cane-land, on an average, is ſeven hogſheads of 16 cwt. to ten acres, which are cut every year.

The crop time in the ſugar iſlands is the ſeaſon of feſtivity, both to man and beaſt; for ſo agreeable to the taſte, and ſo nouriſhing to the corporeal frame, is the juice of the cane, that every animal derives health and vigour from its uſe. Such of the negroes as were meagre and ſickly, become ſurpriſingly altered for the better in a few weeks after the mill is ſet in action. The labouring horſes, oxen, and mules, though almoſt conſtantly at work during this ſeaſon, yet, in conſequence of eating plentifully of the green tops of this invigorating plant, and being indulged with ſome of the ſcummings from the boiling-houſe, improve more than at any other period of the year. Even pigs and poultry fatten on the refuſe. In ſhort, during crop-time, plenty and induſtrious cheerfulneſs every where prevail in ſuch a high degree on a well-regulated plantation, as conſiderably to ſoften the hardſhips of ſlavery, and induce an impartial ſpectator to conclude, that the miſeries of life are ſometimes exaggerated through the deluſive medium of fancy.

Such planters as are not fortunately furniſhed with the means of grinding their canes by water, are at this ſeaſon frequently impeded by the failure or inſufficiency of their mills; for though a ſugar-mill is a very ſimple contrivance, yet great force is requiſite to make it vanquiſh the reſiſtance which it neceſſarily meets with. It principally conſiſts of three upright iron rollers or cylinders, from thirty to forty inches in length, and from twenty to twenty-five inches in diameter; and the middle one, to which the moving power is applied, turns the other two by means of cogs. The canes, which are previouſly cut ſhort and tied into bundles, are twice compreſſed between theſe rollers; for after they have paſſed through the firſt and ſecond rollers, they are turned round the middle one by a piece of frame-work of a circular form, which is called in Jamaica the dumb-returner, and forced back through the ſecond and third. By this operation they are ſqueezed completely dry, and ſometimes even reduced to powder. The cane-juice is received in a leaden-bed, and thence conveyed into a veſſel called the receiver. The refuſe, or macerated rind of the cane, which is called cane-traſh, ſerves for fuel to boil the liquor.

The juice from the mill uſually contains eight parts of pure water, one part of ſugar, and one part made up of groſs oil, and mucilaginous gum, with a portion of eſſential oil. The proportions are taken at a medium; for ſome juice has been ſo rich as to make a hogſhead or ſixteen hundred weight of ſugar from thirteen hundred gallons, and ſome is ſo watery as to require more than double that quantity. The richer the juice is, the leſs it abounds with redundant oil and gum; ſo that very little knowledge of the contents of any other quantity can be obtained by the moſt exact analyſis of any one quantity of juice.

The following matters are likewiſe uſually contained in cane-juice. Some of the green tops, which ſerve to tie the canes in bundles, are often ground in, and yield a raw acid juice exceedingly diſpoſed to ferment and render the whole liquor ſour. Beſides theſe they grind in ſome pieces of the ligneous part of the cane, ſome dirt, and laſtly, a ſubſtance of ſome importance, which may be called the cruſt. This ſubſtance is a thin black coat of matter that ſurrounds the cane between the joints, beginning at each joint, and gradually growing thinner the farther from the joint upwards, till the upper part between the joints appears entirely free from it, and reſumes its bright yellow colour. It is a fine black powder, that mixes with the clammy exudations from the cane; and as the fairneſs of the ſugar is one ſymptom of its goodneſs, a ſmall quantity of this cruſt muſt very much prejudice the commodity.

The ſugar is obtained by the following proceſs: The juice or liquor runs from the receiver to the boiling-houſe, along a wooden gutter lined with lead. In the boiling-houſe, it is received into one of the copper pans or cauldrons called clarifiers. Of theſe there are generally three; and their dimenſions are determined by the power of ſupplying them with liquor. There are water-mills that will grind with great facility ſufficient for thirty hogſheads of ſugar in a week. Methods of quick boiling cannot be diſpenſed with on plantations thus fortunately provided; for otherwiſe the cane liquor would unavoidably become tainted before it could be expoſed to the fire. The pureſt cane-juice will not remain twenty minutes in the receiver without fermenting. Hence, clarifiers are ſometimes ſeen of one thouſand gallons each. But on plantations that during crop-time make from fifteen to twenty hogſheads of ſugar a week, three clarifiers of three or four hundred gallons each are ſufficient. The liquor, when clarified, may be drawn off at once, with pans of this ſize, and there is leiſure to cleanſe the veſſels every time they are uſed. Each clarifier is furniſhed either with a ſyphon or cock for drawing off the liquor. It has a flat bottom, and is hung to a ſeparate fire, each chimney having an iron ſlider, which, when ſhut, cauſes the fire to be extinguiſhed through want of air *.

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* The clarifiers are generally placed in the middle or at one end of the boiling-houſe. When they are

As ſoon as the ſtream from the receiver has filled the clarifier with freſh liquor, and the fire is lighted, the temper, which is generally Briſtol white-lime in powder, is ſtirred into it. This is done, in order to neutralize the ſuperabundant acid, and to get rid of which is the great difficulty in ſugar-making. Alkali, or lime, generally effects this; and at the ſame time part of it is ſaid to become the baſis of the ſugar. Mr. Edwards affirms that it affects both the ſmell and taſte of the ſugar. It falls to the bottom of the pans in a black inſoluble matter, which ſcorches the bottom of the veſſels, and cannot without difficulty be detached from them. But in order that leſs of the lime may be precipitated to the bottom, little more than half a pint of Briſtol lime ſhould be allowed to every hundred gallons of liquor, and Mr. Bouſie's method of diſſolving it in boiling water previous to mixing it with the cane-juice ſhould be adopted *.

As the force of the fire increaſes, and the liquor grows hot, a ſcum is thrown up, which is formed of the gummy matter of the cane, with ſome of the oil, and ſuch impurities as the mucilage is able to entangle. The heat is now ſuffered to increaſe gradually till it nearly riſes to the heat of boiling water. The liquor, however, muſt by no means be ſuffered to boil. When the ſcum begins to riſe into bliſters, which break into white froth, and generally appear in about forty minutes, it is known to be ſufficiently heated. Then the damper is applied, and the fire extinguiſhed; and if circumſtances will admit, the liquor after this is ſuffered to remain a full hour undiſturbed. In the next place, it is carefully drawn off, either by a ſyphon, which draws up the clear fluid through the ſcum, or by means of a cock at the bottom. In either caſe, the ſcum ſinks down without breaking as the liquor flows; for its tenacity prevents any admixture. The liquor is received into a gutter or channel, which conveys it to the evaporating boiler, commonly called the grand copper, and if produced at firſt from good and untainted canes, it will then appear almoſt tranſparent.

In the grand or evaporating copper, which ſhould be ſufficiently large to receive the net contents of one of the clarifiers, the liquor is ſuffered to boil, and the ſcum, as it riſes, is continually taken off by large ſcummers, till the liquor becomes finer and ſomewhat thicker. This operation is continued till the ſubject is ſo reduced in quantity, that it may be contained in the next or ſecond copper, into which it is then laded. The liquor is now almoſt of the colour of Madeira wine. In the ſecond copper the boiling and ſcumming are continued; and if the ſubject is not ſo clean as is expected, lime-water is thrown into it. This addition not only ſerves to give more temper, but likewiſe to dilute the liquor, which ſometimes thickens too faſt to permit the feculencies to riſe in the ſcum. When the froth in boiling ariſes in large bubbles, and is not much diſ-

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are placed at one end, the boiler called the teache is placed at the other, and three boilers are uſually ranged between them. The teache commonly holds from 70 to 100 gallons, and the boilers between the clarifiers and teache diminiſh in ſize from the firſt to the laſt. But when the clarifiers are in the middle, there is generally a ſet of three boilers on each ſide, which in effect form a double boiling-houſe. This arrangement is very neceſſary on large eſtates.

* Mr. Bouſie, to whom, for his improvements in the art of ſugar-boiling, the Aſſembly of Jamaica gave 1,000l., in a paper which he diſtributed among the members recommends the uſe of a vegetable alkali, or aſhes of wood, ſuch as pimento tree, dumb cane, fern tree, caſhew or logwood, as affording a better temper than quick-lime. Afterwards, however, he was convinced that ſugar formed on the baſis of fixed alkaline ſalts never ſtands the ſea, unleſs ſome earth is united to the ſalts. Such earth as approaches neareſt to the baſis of alum, Mr. Edwards thinks, would be moſt proper; and it deſerves to be inquired how far a proper mixture of vegetable alkaline ſalts and lime might prove a better temper than either lime or alkaline ſalts alone. In ſome parts of Jamaica, where the cane-liquor was exceedingly rich, Mr. Bouſie made very good ſugar without a particle of temper.

coloured, the liquor is ſaid to have a favourable appearance in the ſecond copper. When in conſequence of ſuch ſcumming and evaporation, the liquor is again ſo reduced that it may be contained in the third copper, it is laded into it, and ſo on to the laſt copper, which is called the teache. This arrangement ſuppoſes four boilers or coppers, beſides the three clarifiers.

In the teache the ſubject undergoes another evaporation, till it is ſuppoſed boiled enough to be removed from the fire. This operation is uſually called ſtriking, i. e. lading the liquor, which is now exceeding thick, into the cooler.

The cooler, of which there are generally ſix, is a ſhallow wooden veſſel, about eleven inches deep, ſeven feet in length, and from five to ſix feet wide. A cooler of this ſize holds a hogſhead of ſugar. Here the ſugar grains, i. e. as it cools, it runs into a coarſe irregular maſs of imperfect cryſtals, ſeparating itſelf from the melaſſes. From the cooler it is taken to the curing-houſe, where the melaſſes drains from it*.

But here it may be proper to notice the rule for knowing when the ſubject is fit to be laded from the teache to the cooler. Many of the negro boilers, from long habit, gueſs accurately by the eye alone, judging by the appearance of the grain on the back of the ladle; but the practice generally adopted is to judge by what is called the touch, i. e. taking up with the thumb a ſmall portion of the hot liquor from the ladle, and, as the heat diminiſhes, drawing with the fore-finger the liquid into a thread. This thread will ſuddenly break and ſhrink from the thumb to the ſuſpended finger, in different lengths, according as the liquor is more or leſs boiled. A thread of a quarter of an inch long generally determines the proper boiling height for ſtrong muſcovado ſugar†.

The curing-houſe is a large airy building, provided with a capacious melaſſes ciſtern, the ſides of which are ſloped and lined with terras, or boards. A frame of maſſy joiſt-work without boarding is placed over this ciſtern; and empty hogſheads without headings are ranged on the joiſts of this frame. Eight or ten holes are bored in the bottoms of theſe hogſheads, and through each of the holes the ſtalk of a plantain leaf is thruſt ſix or eight inches below the joiſts, and is long enough to ſtand upright above the top of the hogſhead. Into theſe hogſheads the maſs from the cooler is put, which is called potting; and the melaſſes drains through the ſpungy ſtalk, and drops into the ciſtern, from whence it is occaſionally taken for diſtillation. In the ſpace of three weeks, the ſugar becomes tolerably dry and fair. It is then ſaid to be cured, and the proceſs is finiſhed.

Sugar thus obtained is called muſcovado, and is the raw material from whence the Britiſh ſugar-bakers chiefly make their loaf or refined lump. There is another ſort which was formerly much uſed in Great-Britain for domeſtic purpoſes, and was generally known by the name of Liſbon ſugar. In the Weſt-Indies it is called clayed ſugar; and the proceſs of making it is as follows:

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* It is neceſſary to obſerve in this place, that, in order to obtain a large grained ſugar, it muſt be ſuffered to cool ſlowly and gradually. If the coolers are too ſhallow, the grain is injured in a ſurpriſing manner.

† The veſſel called the teache probably derived its name from this practice of trying by the touch (tactio). Some years ago, John Proculus Baker, Eſq. barriſter at law, recommended to the public a method more ſcientific and certain, in a treatiſe which he publiſhed in 1775, entitled An Eſſay on the Art of making Muſcovado Sugar. It is as follows: "Provide a ſmall thin pane of clear crown glaſs, ſet in a frame, which I would call a tryer; on this drop two or three drops of the ſubject, one on the other, and carry your tryer out of the boiling-houſe into the air. Obſerve your ſubject, and more particularly whether it grains freely, and whether a ſmall edge of melaſſes ſeparates at the bottom. I am well ſatisfied that a little experience will enable you to judge what appearance the whole ſkip will put on when cold, by this ſpecimen which is alſo cold. This method is uſed by chemiſts, to try evaporated ſolutions of all other ſalts: it may ſeem therefore ſomewhat ſtrange, it has not been long adopted in the boiling-houſe."

A quantity of ſugar from the cooler is put into conical pots or pans, which the French call formes, with the points downwards, having a hole about half an inch in diameter at the bottom, for the melaſſes to drain through, but which at firſt is cloſed with a plug. As ſoon as the ſugar in theſe pots is cool, and becomes a fixed body, which is known by the middle of the top falling in, the plug is taken out, and the pot placed over a large jar, intended to receive the ſyrup or melaſſes that drains from it. In this ſtate it is left as long as the melaſſes continues to drop, when a ſtratum of clay is ſpread on the ſugar, and moiſtened with water. This imperceptibly oozing through the pores of the clay, dilutes the melaſſes, in conſequence of which more of it comes away than from ſugar cured in the hogſhead, and the ſugar of courſe becomes ſo much whiter and purer. According to Sloane, the proceſs was firſt diſcovered in Braſil, by accident: "A hen (ſays he) having her feet dirty, going over a pot of ſugar, it was found under her feet to be whiter than elſewhere." The reaſon aſſigned why this proceſs is not univerſally adopted in the Britiſh ſugar iſlands, is this, that the water which dilutes and carries away the melaſſes, diſſolves and carries with it ſo much of the ſugar, that the difference in quality does not pay for the difference in quantity. It is probable however, that the French planters are of a different opinion; for upwards of four hundred of the plantations of St. Domingo have the neceſſary apparatus for claying, and actually carry on the ſyſtem.

Sugar is very ſoluble in water, and is a good medium for uniting that fluid with oily matters. It is much uſed for domeſtic purpoſes, and appears upon the whole to be a valuable and wholeſome article of food, the uſes of which are moſt probably reſtricted by its high price. This price may in a certain degree ariſe from the nature of the article and its original coſt; but is no doubt in a great meaſure owing to the inhuman and waſteful culture by ſlaves, and the abſurd principles of European colonization, duties, draw-backs, and bounties, which have the effect to create unnatural monopolies, and to prevent commerce from finding its level. This is eminently the caſe with regard to our Weſt-India iſlands, and their produce.

One very extenſive uſe of ſugar and ſaccharine juices conſiſts in the formation of ardent ſpirit, an article which, all things conſidered, is perhaps a curſe to ſociety. The wines or beers of pure ſugar ferment ſo rapidly, that they can ſcarcely be kept, but are for the moſt part made for immediate uſe. I do not know of any beer of pure ſugar, which is ſtored and kept for ſale. See Spirit Ardent, Beer, Wine.

Modern chemiſts have made various experimental enquiries with this ſubſtance, for which ſee Acid of Sugar, and Acid of Sugar Empyreumatic.

SUGAR OF LEAD. See Lead.

SUGAR OF MILK. See Milk.

SULPHUR, or brimſtone, is a well known, hard, brittle, inflammable ſubſtance, of an opake yellow colour. It is found more or leſs pure in the neighbourhood of volcanos; where moſt probably it is always expelled from ſome previous ſtate of combination, by the heat of ſubterraneous fires. It is a very common ingredient in a great variety of minerals and ores; but it is extracted for ſale chiefly from a ſtone called pyrites.

In order to obtain ſulphur from pyrites, this mineral ought to be expoſed to a heat ſufficient to ſublime the ſulphur, or to make it diſtil in veſſels, which muſt be cloſe to prevent its burning.

Sulphur is extracted from pyrites at a work at Schwartzemberg, in Saxony, in the high country of the mines, and in Bohemia, at a place called Alten-Sattel.

The furnaces employed for this operation are deſcribed by Macquer. They are oblong, like vaulted galleries; and in the vaulted roofs are made ſeveral openings. Theſe are called furnaces for extracting ſulphur.

In theſe furnaces are placed earthen-ware tubes, filled with pyrites broken into pieces, of the ſize of ſmall nuts. Each of theſe tubes contains about fifty pounds of pyrites. They are placed in the furnace almoſt horizontally, and have ſcarcely more than an inch of deſcent. The ends, which come out of the furnace five or ſix inches, become gradually narrower. Within each tube is fixed a piece of baked earth, in form of a ſtar, at the place where it begins to become narrower, in order to prevent the pyrites from falling out, or choaking the mouth of the tube. To each tube is fitted a receiver, covered with a leaden plate, pierced with a ſmall hole to give air to the ſulphur. The other end of the tube is exactly cloſed. A moderate fire is made with wood, and in eight hours the ſulphur of the pyrites is found to have paſſed into the receivers.

The reſiduum of the pyrites, after the diſtillation, is drawn out at the large end, and freſh pyrites is put in its place. From this reſiduum, which is called burnings of ſulphur, vitriol is extracted. See Acid Vitriolic.

The eleven tubes into which are put, at three ſeveral diſtillations, in all nine quintals, or 900 pounds of pyrites, yield from 100 to 150 pounds of crude ſulphur, which is ſo impure as to require to be purified by a ſecond diſtillation.

This purification of crude ſulphur is alſo done in a furnace in form of a gallery, in which five iron cucurbits are arranged on each ſide. Theſe cucurbits are placed in a ſloping direction, and contain about eight quintals and a half of crude ſulphur. To them are luted earthen tubes, ſo diſpoſed as to anſwer the purpoſe of capitals. The noſe of each of theſe tubes is inſerted into an earthen pot, called the forerunner. This pot has three openings; namely, that which receives the noſe of the tube; a ſecond ſmaller hole, which is left open to give air; and a third in its lower part, which is ſtopped with a wooden peg.

When the preparations are made, a fire is lighted about ſeven o'clock in the evening, and is a little abated as ſoon as the ſulphur begins to diſtil. At three o'clock in the morning, the wooden pegs, which ſtop the lower holes of the forerunners, are for the firſt time drawn out, and the ſulphur flows out of each of them into an earthen pot with two handles placed below for its reception. In this diſtillation the fire muſt be moderated and prudently conducted; otherwiſe leſs ſulphur would be obtained, and it would alſo be of a gray colour, and not of the fine yellow which it ought to have when pure. The ordinary loſs in the purification of eight quintals of crude ſulphur is, at moſt, one quintal.

When all the ſulphur has flowed out, and has cooled a little in the earthen pots, it is caſt into moulds made of beech-tree, which have been previouſly dipped in water, and ſet to drain. As ſoon as the ſulphur is cooled in the moulds, they are opened, and the cylinders of ſulphur are taken out and put up in caſks. Theſe are called roll brimſtone.

As ſulphur exiſts not only in pyrites, but alſo in moſt metallic minerals, it is evident that it might be obtained by works in the large way from the different ores which contain much of it, and from which it muſt be ſeparated previouſly to their fuſion: but as ſulphur is of little value, the trouble of collecting it from ores is ſeldom taken. Smelters are generally ſatisfied with freeing their ores from it, by expoſing them to a fire ſufficient to expel it. This operation is called torrefaction, on roaſting of ores. See Ores.

There are, however, ores which contain ſo much ſulphur, that part of it is actually collected in the ordinary operation of roaſting, without much trouble for that purpoſe. Such is the ore of Ramelſberg, in the county of Hartz.

This ore, which is of lead containing ſilver, is partly very pure, and partly mixed with cupreous pyrites and ſulphur; hence it is neceſſary to roaſt it.

The roaſting is performed by laying alternate ſtrata of ore and wood upon each other in an open field, taking care to diminiſh the ſize of the ſtrata as they riſe higher, ſo that the whole maſs ſhall be a quadrangular pyramid truncated above, whoſe baſe is about thirty-one feet ſquare. Below, ſome paſſages are left open, to give free entrance to the air; and the ſides and top of the pyramid are covered over with ſmall ore, to concentrate the heat and make it laſt longer. In the centre of this pyramid there is a channel, which deſcends vertically from the top to the baſe. When all is properly arranged, ladle-fulls of red hot ſcoria from the ſmelting furnace are thrown down the channel, by which means the ſhrubs and wood, placed below for that purpoſe, are kindled, and the fire is from them communicated to all the wood of the pile, which continues burning till the third day. At that time the ſulphur of the mineral becomes capable of burning ſpontaneouſly, and of continuing the fire after the wood is conſumed.

When this roaſting has been continued fifteen days, the mineral becomes greaſy, that is, it is covered over with a kind of varniſh: twenty or twenty-five holes or hollows are then made in the upper part of the pile, in which the ſulphur is collected. From theſe cavities the ſulphur is taken out thrice every day, and thrown into water. This ſulphur is not pure, but crude, and is therefore ſent to the manufacturers of ſulphur to be purified in the manner above related.

As this ore of Ramelſberg is very ſulphureous, the firſt roaſting, which we are now deſcribing, laſts three months; and during this time if much rain has not fallen, or if the operation has not failed by the pile falling down or cracking, by which the air has ſo much free acceſs that the ſulphur is burnt and conſumed, from ten to twenty quintals of crude ſulphur are by this method collected.

The ſulphur of this ore, like that of moſt others, was formerly neglected, till in the year 1570 a perſon employed in the mines, called Chriſtopher Sauder, diſcovered the method of collecting it, nearly as it is done at preſent.

Metallic minerals are not the only ſubſtances from which ſulphur is extracted; this matter is diffuſed in the earth in ſuch quantities, that the metals cannot abſorb it all. Some ſulphur is found quite pure, and in different forms, principally in the neighbourhood of volcanos, in caverns, and in mineral waters. Such are the opake kind, called virgin ſulphur; the tranſparent kind, called ſulphur of quito; and the native flowers of ſulphur, as thoſe of the waters of Aix-la-Chapelle. It is alſo found mixed with different earths. Here we may obſerve, that all thoſe kinds of ſulphur which are not mineralized by metallic ſubſtances, are found near volcanos, or hot mineral waters, and conſequently in places where nature ſeems to have formed great ſubterranean laboratories, in which ſulphureous minerals may be analyzed and decompoſed, and the ſulphur ſeparated in the manner in which it is done in the ſmall way in our works and laboratories. However that may be, certainly one of the beſt and moſt famous ſulphur mines in the world is that called Solfatara. The Abbé Nollet has publiſhed, in the Memoirs of the Academy, ſome intereſting obſervations upon this ſubject, of which Macquer gives the following abridgment:

Near Puzzoli, in Italy, is that great and famous mine of ſulphur and alum, called at preſent Solfatara. It is a ſmall oval plain, the greateſt diameter of which is about 400 yards, raiſed about 300 yards above the level of the ſea. It is ſurrounded by high hills and great rocks, which fall to pieces, and whoſe fragments form very ſteep banks. Almoſt all the ground is bare and white, like marle; and is every where ſenſibly warmer than the atmoſphere in the greateſt heat of ſummer; ſo that the feet of perſons walking there are burnt through their ſhoes. It is impoſſible not to obſerve the ſulphur there; for every where may be perceived by the ſmell a ſulphureous vapour, which riſes to a conſiderable height, and gives reaſon to believe that there is a ſubterraneous fire below, from which that vapour proceeds.

Near the middle of this field there is a kind of baſon three or four feet lower than the reſt of the plain, in which a ſound may be perceived when a perſon walks on it, as if there were under his feet ſome great cavity, the roof of which was very thin. After that, the lake Agnano is perceived, whoſe waters ſeem to boil. Theſe waters are indeed hot, but not ſo hot as boiling water. This kind of ebullition proceeds from vapours which riſe from the bottom of the lake, which being ſet in motion by the action of ſubterranean fires, have force enough to raiſe all that maſs of water. Near this lake there are pits, not very deep, from which ſulphureous vapours are exhaled. Perſons who have the itch come to theſe pits, and receive the vapours in order to be cured. Finally, there are ſome deeper excavations, whence a ſoft ſtone is procured which yields ſulphur. From theſe cavities vapours exhale, and iſſue out with noiſe, and which are nothing elſe than ſulphur ſubliming through the crevices. This ſulphur adheres to the ſides of the rocks, where it forms enormous maſſes: in calm weather the vapours may be evidently ſeen to riſe twenty-five or thirty feet from the ſurface of the earth.

Theſe vapours, attaching themſelves to the ſides of rocks, form enormous groups of ſulphur, which ſometimes fall down by their own weight, and render theſe places of dangerous acceſs.

In entering the Solfatara, there are warehouſes and buildings erected for the refining of ſulphur.

Under a great ſhed, or hangar, ſupported by a wall behind, open on the other three ſides, the ſulphur is procured by diſtillation from the ſoft ſtones we mentioned above. Theſe ſtones are dug from under ground; and thoſe which lie on the ſurface of the earth are neglected. Theſe laſt are, however, covered with a ſulphur ready formed, and of a yellow colour; but the workmen ſay they have loſt their ſtrength, and that the ſulphur obtained from them is not of ſo good a quality as the ſulphur obtained from the ſtones which are dug out of the ground.

Theſe laſt-mentioned ſtones are broken in lumps, and put into pots of earthen ware, containing each about twenty pints, Paris meaſure. The mouths of theſe pots are as wide as their bottoms; but their bellies, or middle parts, are wider. They are covered with a lid of the ſame earth, well luted, and are arranged in two parallel lines along two brick walls, which form the two ſides of a furnace. The pots are placed within theſe walls; ſo that the centre of each pot is in the centre of the thickneſs of the wall, and that one end of the pots overhangs the wall within, while the other end overhangs the wall without. In each furnace ten of theſe pots are placed; that is, five in each of the two walls which form the two ſides of the furnace. Betwixt theſe walls there is a ſpace of fifteen or eighteen inches; which ſpace is covered by a vault reſting on the two walls. The whole forms a furnace ſeven feet long, two feet and a half high, open at one end, and ſhut at the other, excepting a ſmall chimney, through which the ſmoke paſſes.

Each of theſe pots has a mouth in its upper part without the furnace, in order to admit a tube of eighteen lines in diameter, and a foot in length, which communicates with another pot of the ſame ſize placed without the building, and pierced with a round hole in its baſe of fifteen or eighteen lines diameter. Laſtly, to each of theſe laſt-mentioned pots there is a wooden tub placed below, on a bench made for that purpoſe.

Four or five of theſe furnaces are built under one hangar or ſhed. Fires are kindled in each of them at the ſame time; and they are thrown down after each diſtillation, either that the pots may be renewed, or that the reſiduums may be more eaſily taken out.

The fire being kindled in the furnace, heats the firſt pots containing the ſulphureous ſtones. The ſulphur riſes in fumes into the upper part of the pot, whence it paſſes through the pipe of communication into the external veſſel. There the vapours are condenſed, become liquid, and flow through the hole below into the tub, from which the ſulphur is eaſily turned out, becauſe the form of the veſſel is that of a truncated cone, whoſe narrower end is placed below, and becauſe the hoops of the tub are ſo faſtened, that they may be occaſionally looſened. The maſs of ſulphur is then carried to the buildings mentioned before, where it is remelted for its purification, and caſt into rolls, ſuch as we receive it.

For accurate purpoſes, ſublimation is neceſſary to deprive ſulphur of the accidental impurities it may contain. This may be done in an earthen cucurbit ſet on a ſand bath, with a head properly adapted. The ſulphur riſes by a very gentle heat, little more than is ſufficient to melt it; and the fine ſublimate thus obtained is called flowers of brimſtone.

Water has no immediate action on ſulphur. It is ſaid, however, to ſoften the outſide by long contact with it; and if ſulphur be heated nearly to ſuch a degree as to ſet it on fire, and then poured into water, it becomes ſoft, and partly tranſparent. In proceſs of time it recovers its original hardneſs and opacity. If ſteam of water be paſſed over ſulphur contained in a heated earthen tube, inflammable air is extricated either from the ſulphur or the water, and comes out at the end of the tube*. The experiment is troubleſome, on account of the ſulphur ſubliming.

The combinations of ſulphur with earths or alkalis are called hepars, or livers of ſulphur, from their colour. There is no perceptible action between ſulphur and ſiliceous earth. Argillaceous earth has very little action upon it in the direct way; but lime unites readily with it. If freſh quick-lime and flowers of ſulphur be mixed, and water be added a little at a time, the heat of the lime will be ſufficient to produce the combination. On addition of more water it becomes reddiſh, and emits a fetid ſmell of rotten eggs, which is common to all the hepars. The more cauſtic the lime, the deeper the colour of the hepar. The pure fixed alkalis decompoſe calcareous hepar, by virtue of their ſtronger affinity to the ſulphur; and any acid whatever decompoſes it, by attracting the lime, the ſulphur at the ſame time falling to the bottom in the form of a ſubtle powder, formerly called magiſtery of ſulphur.

Pure ponderous earth boiled in water with ſulphur has but little action upon it: but in the dry way, when ponderous ſpar, or the combination of vitriolic acid and ponderous earth, is ſtrongly heated in a crucible with charcoal, a coherent maſs is formed, which is ſoluble in water, with the ſmell and other hepatic characters; and if any acid be added which will form a ſoluble ſalt with the ponderous earth, a precipitate of ſulphur will be obtained.

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* Prieſtley, vi. 150.

If a ſmall quantity of magneſia, and an equal quantity of flowers of ſulphur, be incloſed in a veſſel perfectly filled up with diſtilled water, and well ſtopped, and then expoſed to heat by immerſion in boiling water for ſeveral hours, a combination will take place; and the water will contain a magneſian liver of ſulphur, from which the earth may be precipitated by the addition of an alkali, which will unite with the ſulphur: or the ſulphur may be precipitated by an acid, which will combine with the earth.

The fixed alkalis combine very readily with ſulphur, either in the moiſt or dry way, whether they be in a pure or cauſtic ſtate, or combined with fixed air; though more ſtrongly in the former than the latter caſe. If a ſolution of fixed alkali in water be boiled with half its weight of powdered ſulphur, a combination takes place, and liver of ſulphur is formed. Or if equal parts of dry alkali and powdered ſulphur be melted in a crucible, and poured out on a flat poliſhed ſtone, as ſoon as the fuſion is complete the combination will be of a liver colour, and is the ſolid hepar. If it be made with a pure or cauſtic alkali, its colour is deeper, and its characteriſtic properties more intenſe, than when a mild alkali is uſed. A ſolution of the ſolid hepar in water forms preciſely the ſame ſubſtance as the preparation made in the moiſt way.

The peculiar fetid ſmell of the ſolid hepar when moiſtened, or of its ſolution, is produced by the emiſſion of a permanently elaſtic fluid, called hepatic air. This ſmell when ſtrong is inſupportable, and ſuddenly deſtroys animal life. Hepatic air is very ſoluble in water, which it converts into a ſtate perfectly reſembling that of the ſulphureous mineral ſprings. It renders ſyrup of violets green, blackens the calces of lead and biſmuth, and the ſurface of ſilver. Vital air decompoſes it, and cauſes ſulphur to be depoſited. It detonates with vital air when ſet on fire. It is not clearly aſcertained in what manner the ſulphur is ſuſpended in hepatic air. Sulphur melted by the burning glaſs in inflammable air over mercury, produces a fluid which has the properties of hepatic air. See LIVER OF SULPHUR, AIR HEPATIC.

The acidification of ſulphur by burning has been mentioned and explained under the article ACID VITRIOLIC. The proceſs of combuſtion is ſaid to be performed in ſome manufactories in very large glaſs globes. But the moſt uſual method in England is, as I am informed, by chambers lined with lead. Of theſe the annotator on Macquer's Dictionary gives the following account. It is ſaid that the proceſs was brought forward in England by the celebrated Dr. Ward.

The greateſt part of the vitriolic acid now employed is obtained by burning ſulphur. The vapours of burning ſulphur are the volatile vitriolic, or ſulphureous acid. Theſe are very difficultly condenſible. For which reaſon very large veſſels and much time are required in this operation. In great works leaden veſſels are uſed, called houſes, of a priſmatic form, of which the altitude is about ten feet, and the baſe, which is a rectangle, is ſix feet long and four feet broad. The bottom of each of theſe veſſels is covered with a little water to aſſiſt the condenſation of the vapour. Above the water is placed a ſmall veſſel capable of containing a few pounds of ſulphur, to which a ſmall portion of nitre is added; becauſe by this addition a larger quantity of ſulphur may be burnt without acceſs of freſh air. The veſſels are to be filled with the vapour of hot water, and their ſides wetted with the condenſed ſteam; then the ſulphur is to be kindled by touching it with a red hot iron: the vapour of the burning ſulphur riſes ſlowly; and when it has riſen as high as the mouth of the great veſſel, this muſt be ſtopped, or very nearly ſtopped, that the vapour may be confined. The ſulphur continues to burn till the air contained within the veſſel and the nitre be no longer capable of maintaining the combuſtion. The vapour remains a conſiderable time before it be entirely condenſed, notwithſtanding that this condenſation is facilitated by the water in the veſſel, and eſpecially by the ſteam of water with which the veſſel was previouſly filled. When all the vapour of the ſulphureous acid is at laſt condenſed, the ſulphur is to be again kindled, and more added if it be neceſſary, and the proceſs repeated as before. When a ſufficient quantity of acid is collected, it is to be taken out of the veſſel; and after it has loſt its ſulphureous or volatile quality by expoſure to air, it is concentrated and rectified by diſtillation.

Mr. Delametherie, in one of his preliminary diſcourſes to the Journal de Phyſique, to which I am not at preſent able to refer, aſſerts that the Engliſh manufacturers contrive to burn ſulphur and condenſe the product into vitriolic acid, without making uſe of nitre. The moſt effective expedient is ſaid to conſiſt in paſſing the elaſtic product through a body of water. But Mr. Chaptal, whoſe knowledge and ſkill in chemiſtry, as well as the extenſive opportunities he poſſeſſes of making experiments in the large way, entitle him to the utmoſt reſpect, has in the ſecond volume of the Annales de Chimie given an account of ſome phenomena attending the combuſtion of ſulphur, which ſhew that ſome very conſiderable difficulties attend this proceſs.

When ſulphur is burned in a fire conſtructed on the outſide of a chamber of lead, and the current of fumes and ſmoke is directed into the chamber, the product according to the management will be either ſublimed ſulphur, ſoft ſulphur, ſulphureous acid, or the perfect vitriolic acid.

When the current of air is rapid, and the combuſtion ſpeedy, a quantity of ſulphur is carried into the chamber, and depoſited without any perceptible alteration.

If the current of air be moderated, the combination between the ſulphur and vital air becomes ſomewhat more exact; the ſulphur is partly acidified, and is depoſited in a pellicle on the ſurface of the water. This pellicle is flexible like a ſkin, and may be turned and handled in the ſame manner. Chaptal was frequently obliged to take it out with a cake at its early depoſition, when it reſembles ſpider's webs.

If the current of air be ſtill leſs rapid, and its vital part be allowed the time neceſſary to combine ſtill more effectually with the ſulphur, the product is the ſulphureous vitriolic acid, which preſerves its elaſtic form in the temperature of the atmoſphere, provided water be not preſent, but may be condenſed by extreme cold, as Monge has ſhewn. It is the vitriolic acid air.

If the combuſtion be yet more checked, and, as Chaptal expreſſes it, if the air be ſuffered to digeſt upon the inflamed ſulphur, the reſult is vitriolic acid. This laſt combination may be facilitated by the mixture of ſaltpetre, which abundantly furniſhes vital air in the denſe ſtate.

The addition of ſaltpetre to the ſulphur adds very conſiderably to the price of the oil of vitriol of commerce. Chaptal affirms that he has made a prodigious number of variations in the manner of burning ſulphur for the purpoſe of diminiſhing the proportion of this ſalt. The reſults of theſe experiments are as follow:

In 1785 a ſquare chamber lined with lead was prepared for this purpoſe. Its dimenſions were thirty feet (de trente pieds de dimenſion), by which I take it for granted the author means a cube meaſuring thirty feet in its ſide. He at firſt adapted to one of the angles a kind of reverberatory furnace, of which the fire-place was two feet in diameter, and the chimney was directed into the chamber. He was aſtoniſhed at the facility with which ſulphur was burned in this furnace. The combuſtion was kept up by a proper ſupply for ſeven ſucceſſive days, at the end of which time a ſmell ſo ſtrong was emitted round the chamber, that the workmen could no longer proceed. This ſmell was ſo penetrating that it excited tears, and ſneezing of ſuch a convulſive kind as to force blood from the noſe. The fire was therefore diſcontinued, and three or four days afterwards the door of the chamber was opened; whence a gas eſcaped ſo ſubtle and penetrating, that its effect on the ſkin of the face produced a ſenſation reſembling that of ſmall pins darted into the fleſh. As ſoon as it was practicable to viſit the interior part, the water was found to be covered by a membrane of conſiderable thickneſs, and ſufficiently tenacious to admit of its being drawn about upon the ſurface of the liquid. This membrane was covered with a ſtratum of flowers of ſulphur. The water marked o on the aerometer of Baumé, and was ſcarcely acidulated, whereas the eleven quintals and thirty-five pounds of ſulphur which had been burned ought to have raiſed the water to the denſity of nine degrees, according to former obſervations, if the vitriolic acid had been produced. This experiment, varied and repeated ſeveral times in a ſmall chamber of fifteen by twenty feet ſquare, conſtantly afforded the ſame reſults.

It was therefore requiſite to moderate the current of air, that a greater portion of vital air might combine with the ſulphur. This was expected to be accompliſhed by making the aperture of communication between the furnace and the chamber a ſquare of four feet, and admitting the external air to the furnace through a ſmall door furniſhed with a regiſter. The combuſtion was neither ſo eaſily effected nor ſo rapid as before; but the deteſtable ſmell which iſſued from the internal part of the chamber rendered it neceſſary to ſuſpend the combuſtion for ſeveral days together. An iſſue was likewiſe given to the vapours ſeveral times, by opening the door, and leaving it open for a long time. At length with theſe precautions twenty-nine quintals were burned in the ſpace of thirty-three days; and when this chemiſt examined the ſtate of the water, he was not a little ſurpriſed to find that it marked only one degree, and ſcarcely efferveſced with alkalis. There was no pellicle on the water, nor ſulphur ſublimed, which ſhews in his opinion that the ſulphur was converted perfectly enough into ſulphureous acid. Whence it ſhould ſeem that the failure of the experiment muſt have ariſen chiefly from a defect as to the means of condenſation.

It obviouſly appears that theſe means muſt conſiſt in increaſing the ſurfaces of contact of the water and ſulphureous acid. This may be done by mechanical agitation, by paſſing the elaſtic fluid through the water, or by introducing the water in the form of ſteam. The two latter expedients are ſaid to be uſed in the Engliſh works. I do not find that they occurred to Chaptal at the time of making his experiments. From the unſucceſsful iſſue of this laſt experiment he renounced the hope of obtaining vitriolic acid by the vital air of the atmoſphere alone applied to ſulphur, and was more than ever convinced of the neceſſity of the mixture of ſaltpe re.

The firſt effect of the combuſtion of this mixture is a white thick ponderous vapour, ſtrongly acid, which is eaſily precipitated and fixed; whence the external air is ſtrongly drawn in to aſſiſt the combuſtion. This vapour is highly phoſphoric, as may be ſeen by inſpecting a chamber of lead at the moment when it is filled with theſe vapours.

As ſoon as all the vapour is depoſited on the water, or on the ſides, there remains a ſulphureous acid gas, elaſtic, tranſparent, and penetrating, which eſcapes from the internal part of the chamber as ſoon as the door is opened, and is an impediment to the combuſtion. This gas is more abundant, the leſs the proportion of ſaltpetre in the mixture.

When the door of one of theſe leaden chambers is opened, a red vapour is ſeen to come forth, which conſiſts of nitrous air in the act of combination with the vital air of the atmoſphere. It is formed in proportion as the external air penetrates into the chamber.

The nitrous acid thus precipitated corrodes the lead and ſpeedily covers its ſurface with a white calx, which may be employed for the ſame purpoſes as ceruſe.

SUMACH *. Common ſumach (rhus coriaria) is a ſhrub that grows naturally in Syria, Paleſtine, Spain, and Portugal; in the two laſt it is cultivated with great care: its ſhoots are cut down every year quite to the root; and, after being dried, they are reduced to powder by a mill, and thus prepared for the purpoſes of dyeing and tanning. The ſumach cultivated in the neighbourhood of Montpellier is called rédoul or roudou.

The infuſion of ſumach, which is of a greeniſh fawn colour, ſoon becomes brown by expoſure to the air: a ſolution of pot-aſh produces but little change on it while recent; acids brighten its colour, and turn it yellow; ſolution of alum renders it turbid, and produces in it a ſmall quantity of yellow precipitate; the liquor remains yellow.

Sugar of lead produced immediately a conſiderable quantity of yellowiſh precipitate, the ſurface of which was brown; the liquor remained of a clear yellow.

Vitriol of copper produced a copious precipitate of a yellowiſh green, which after ſome hours changed to a browniſh green; the liquor remained clear and ſlightly yellow.

Common vitriol of zinc rendered the liquor turbid, darkened its colour, and produced a deep blue precipitate.

Pure vitriol of zinc did not deepen the colour nearly ſo much; only a ſmall quantity of a browniſh fawn-coloured precipitate was produced.

Sea ſalt at firſt produced no ſenſible change; but after ſome hours, the liquor became ſomewhat turbid, and its colour was rendered a little more clear.

Sumach acts on a ſolution of ſilver juſt as galls do; it reduces the ſilver to its metallic ſtate, and the reduction is favoured by the action of light.

Of all aſtringents, ſumach bears the greateſt reſemblance to galls: the precipitate, however, produced in ſolutions of iron by an infuſion of it, is leſs in quantity than what is obtained by an equal weight of galls; ſo that in moſt caſes it may be ſubſtituted for galls, the price of which is conſiderable, provided we proportionally increaſe its quantity.

Sumach alone gives a fawn colour inclining to green; but cotton ſtuffs which have been impregnated with printer's mordant, that is, acetous alum, take a pretty good and very durable yellow. An inconvenience is experienced in employing ſumach in this way, which ariſes from the fixed nature of its colour; the ground of the ſtuff does not loſe its colour by expoſure on the graſs, ſo that it becomes neceſſary to impregnate all the ſtuff with different mordants to vary the colours, without leaving any part of it white.

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* From Berthollet.

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TALC. Pure magneſia, intimately mixed with nearly twice its weight of ſilex, and leſs than its own weight of clay, produces Venetian talc.

Its colour is white, gray, yellowiſh, or greeniſh; it is ſoft and ſoapy to the touch, and in thin pieces ſemi-tranſparent; it is compoſed of very thin laminæ diſpoſed in a laminar or filamentous form, much tenderer and more brittle than thoſe of mica, but like this it has a metallic luſtre; its hardneſs is ſo inconſiderable that it may be ſcratched with the nail; and its ſpecific-gravity is 2,729.

It does not effervеſce with acids; and is ſoluble therein very difficultly, by particular management, and only in part.

In fire it becomes more brittle and whiter, but is infuſible per ſe by the blowpipe, and ſcarcely fuſible by fixed alkalis, but more completely and with little effervеſcence by borax or microcoſmic ſalt.

This talc contains ſomething leſs than fifty per cent. of ſilex, and about two per cent. of iron. The magneſia is in ſmaller quantity, but it exceeds the clay: the exact proportion was not found by Kirwan.

Muſcovy talc conſiſts of broad, elaſtic, flexible, tranſparent leaves; and differs externally from mica only in being ſofter and more ſoapy to the touch. Kirwan.

TALLOW. I do not know of any experiments which aſcertain a chemical difference between this concrete animal fat, which is chiefly taken from the inteſtines of animals, and other fat oils of the ſame nature. The moſt valuable property of tallow is the conſiderable heat it requires to fuſe it, which is commonly diſtinguiſhed by the term hardneſs. The quantity of ſoot and fetid exhalation emitted from the various kinds of tallow candles brought to market, alſo form a diſtinguiſhing characteriſtic in the uſe of this article, and are accompanied with notable variations in the quantities of light afforded by each. It is an object of no ſmall importance to purify or improve tallow. The tallow-chandlers clear it of fibrous matter and other groſs impurities by careful melting, ſtraining, and the like mechanical management. It is ſaid alſo that they improve its whiteneſs by the addition of alum, the efficacy of which I am much diſpoſed to doubt. It is thought alſo that long keeping, and the action of the external air, improve its hardneſs; but theſe ſlow operations are ill calculated for a manufactory in which the greateſt part of the capital is veſted in the raw material and duty, and very little in the manufacturing proceſs.

The aerated marine acid produces a ſtate in tallow which is ſomewhat nearer to that of wax than before, and a thin ſtratum of tallow expoſed upon an extended ſurface of water becomes likewiſe harder; but the indications theſe proceſſes might afford to the manufacturer have not yet been applied to any extended purpoſes of utility.

TALLOW, MINERAL. See MUMIA.

TAMARINDS. Tamarindi fructus: Tamarindi indicæ, Linn. The fruit of a tree growing in the Eaſt and Weſt Indies, called by C. Bauhin ſiliqua Arabica quæ tamarindus. It is a pod reſembling a bean-cod, including ſeveral hard ſeeds, together with a dark-coloured viſcid pulp of a pleaſant acid taſte: the Eaſt India tamarinds are longer than the Weſt India ſort; the former containing ſix or ſeven ſeeds each, the latter rarely above three or four.

TANNING. The ſeveral kinds of leather are prepared from the ſkins of animals macerated for a long time with lime and water, to promote the ſeparation of the hair and wool, and of the fat and fleſhy parts, in which recourſe is alſo had to the aſſiſtance of mechanical preſſure, ſcraping, and the like. The ſkin, when thus deprived of its more putreſcible part, and brought conſiderably towards the ſtate of mere fibre, is tanned by maceration with certain aſtringent ſubſtances, particularly the bark of the oak-tree. Neumann affirms, that prepared leather, as well as ſkins, affords a large quantity of glue by boiling in water. The Chevalier de St. Real, in a memoir inſerted among thoſe of the Royal Academy of Sciences at Turin, for the years 1788 and 1789, of which an extract by Berthollet is given in the xth volume of the Annales de Chimie, p. 44, gives a number of intereſting experiments reſpecting the tanning of ſkins, to the following effect.

After having exhauſted the ſkin by infuſion and a ſubſequent ſtrong boiling with water, and ſeparating the products obtained by this means, the author has obſerved, that the ſkin then conſiſts of nothing but the mere fibres. In the next place he examined the ſtate of tanned leather by the ſame means. It afforded neither lymph nor jelly, but merely an aſtringent extract which gave a black precipitate when applied to a ſolution of iron. The aſtringent principle of tanned leather could not be exhauſted by long boiling with water, for it at laſt became black when moiſtened with a ſolution of martial vitriol.

The author ſhews, that all the operations performed upon ſkins preliminary to tanning them, conſiſt in ſeparating ſuch matters as are of a different nature from the epidermes and the fibres which conſtitute the ſkin, in order that the aſtringent principle may afterwards be combined with theſe animal fibres. He afterwards examines the different proceſſes of the art of tanning, analyſes their advantages and imperfections, and has ſucceeded in ſimplifying and abridging them, and by that means accelerating the return of capital, of which the inveſtment conſtitutes a large part of the price of leather. With this view, his enquiries were directed to aſcertain what degree of heat is ſufficient to extract the animal jelly, and alſo at what temperature the fibrous texture of the ſkin begins to ſuffer alteration. He aſcertained that the heat proper to diſſolve the animal jelly commences at 48° of Reaumur, which correſponds with 140° of Fahrenheit; and that the fibrous texture is capable of ſuſtaining a degree of heat beyond 60° of Reaumur or 167° of Fahrenheit, without undergoing any alteration in places where the mean temperature of the barometer is 26 inches and 4 lines, I ſuppoſe French meaſure. See MEASURE.

In conſequence of his reſearches and obſervations, the author propoſes to reduce the practice of the art of tanning to the following particulars:

1. The ſkins are to be kept ſeparately immerſed in running water, for a time ſufficient to extract the lymph or ſerum. This period is eaſily aſcertained, by putting a piece of the ſkin into a ſmall quantity of water, and gradually heating it. If it contain ſerum, this matter will be firſt extracted, and afterwards coagulated in the form of ſcum on the ſurface. If therefore no ſcum appear, the ſkins may be conſidered as purified from lymphatic matter.

2. Theſe waſhed and rinced ſkins are then to be transferred into boilers properly adapted for the purpoſe; water is then to be added, and heat applied, ſo that

the temperature of the water may not exceed 60°. The ſkins are to remain in this ſituation for an hour.

3. The ſkins are then to be taken out, and worked in the uſual manner, to clear them of their impurities.

4. After this proceſs they are again to be placed in the boiler, which muſt be ſo diſpoſed, that a conſtant ſtream of water at the temperature of 60° of Reaumur ſhall enter by one cock, and paſs off by another on the oppoſite ſide beneath.

5. The ſkins are to remain in this ſituation until the water that comes off exhibits no veſtige of animal jelly. This is eaſily aſcertained by evaporating a ſmall quantity.

6. The ſkins are then to be taken out, and cleared in the uſual manner of the cellular membrane, and fleſhy parts.

7. Laſtly, they are to be waſhed in a running ſtream, and replaced in a boiler, ſimilar to that juſt mentioned, which is to be filled with the filtered juice of tan, or oak bark. The ſame degree of heat is to be applied, as in the preceding operation, and the ſkins are to remain until they are perfectly tanned. New juice of tan muſt be ſubſtituted from time to time in the room of that which is exhauſted. The exhauſted ſtate is ſhewn by its not having power to afford a black, when a few drops of ſolution of martial vitriol are added.

The operations which are chiefly practiſed for ſtrong leather, conſtitute the firſt part of M. de St. Real's memoir; his ſecond part is employed on the currying, which is performed upon the ſoft or flexible leathers.

This leather is moſt commonly made of calf's ſkin. It is not expoſed for ſo long a time to the action of the tan as the ſtrong leather. The intention of the art of the currier is to ſupple the leather, and to render it uniformly compact and denſe. The moſt remarkable defect in the ordinary preparations is, that the leather is more or leſs penetrable by water. This defect is more eſpecially obſervable in the leather commonly uſed for the ſoles of women's ſhoes, and may evidently be of great prejudice to the health of the wearer. The author propoſes, beſides the common operations of currying, that the ſkin ſhould be impregnated with tallow, by keeping them for a certain time in a bath of this melted ſubſtance, and afterwards paſſing them between rollers. Experience convinced him, that after theſe two operations, which add but little to the price of the leather, it much more effectually reſiſts the action of water, without having ſuffered any diminution of ſtrength.

TAR. If the wood of the turpentine trees be expoſed to the fire, in a veſſel every where cloſed except an aperture at the bottom, as for example in a retort with the neck placed lowermoſt, the reſinous juice melts out by the heat, and at the ſame time contracts an empyreumatic ſmell and taſte: in this ſtate it is tar. Tar is prepared in different parts of Germany, Norway, Sweden, &c. from the pine and the fir-trees, and in ſome places from the larch and the terebinth. The wood is incloſed in a large oven, to the quantity of ten or more loads at a time: this ſtands within another oven called the mantle, the ſpace betwixt them receiving the fire: from the bottom of the inner oven runs a gutter, by which the tar is conveyed off in proportion as it melts out from the wood.

The above account is from Neumann. Chaptal informs us, that tar is obtained from the wood of the trunk, branches and roots of the pine, which are heaped together, covered with turf, and ſet on fire to produce a cloſe combuſtion in the ſame manner as for making charcoal. The oily parts which are diſengaged trickle down, and are received in a gutter which ſerves to convey them to a tub. The moſt fluid part is ſold under the name of huile de Cade; and the thicker part is the tar uſed for paying or painting the parts of ſhipping and other veſſels.

TARRAS, or TERRAS. A volcanic earth uſed as a cement. It does not differ much in its principles from pouzzolana. Kirwan gives the following account of them:

The pouzzolana is of a gray, brown, yellowiſh, or blackiſh colour, looſe, granular, or duſty, and rough, porous, and ſpungy, reſembling a clay hardened in fire, and then reduced to a groſs powder. It contains mixed with it various heterogeneous ſubſtances: its ſpecific gravity is from 2.5 to 2.8, and it is in ſome degree magnetic: it ſcarcely effervеſces with acids, though partially ſoluble in them: it melts eaſily per ſe; but its moſt diſtinguiſhing property is, that it hardens very ſuddenly when mixed with one-third of its weight of lime and water, and forms a cement which is more durable in water than any other. According to Bergman's analyſis, 100 parts of it contain from 55 to 60 of ſiliceous earth, 19 or 20 of argillaceous, 5 or 6 of calcareous, and from 15 to 20 of iron. (3 Berg. 193). It is evidently a martial argillaceous marl that has ſuffered a moderate heat. Its hardening power ariſes from the dry ſtate of the half-baked argillaceous particles, which makes them imbibe water very rapidly, and thus accelerates the deſiccation of the calcareous part; and alſo from the quantity and ſemiphlogiſticated ſtate of the iron contained in it. It is found not only in Italy, but alſo in France, in the provinces of Auvergne and Limoges, and alſo in England and elſewhere.

Tarras or terras is much more compact, hard, porous, and ſpungy than pouzzolana. It is generally of a whitiſh-yellow colour, and contains more heterogeneous particles, as ſpar, quartz, ſhoerl, &c. and ſomething more of a calcareous earth. It effervеſces with acids, is magnetic, and fuſible per ſe. When pulverized, it ſerves as a cement, like pouzzolana. It is found in Germany and Sweden.

TARTAR is depoſited on the ſides of caſks during the fermentation of wine: it forms a lining more or leſs thick, which is ſcraped off. This is called crude tartar, and is ſold in Languedoc from ten to fifteen livres the quintal.

All wines do not afford the ſame quantity of tartar. Neumann remarked, that the Hungarian wines left only a thin ſtratum; that the wines of France afforded more; and that the Rheniſh wines afforded the pureſt and the greateſt quantity.

Tartar is diſtinguiſhed from its colour into red or white: the firſt is afforded by red wine.

The pureſt tartar exhibits an imperfectly cryſtallized appearance; the form is the ſame as Chaptal has aſſigned to the acidulous tartrite of pot-aſh; and it is this quality which is called grained tartar (tartre grenu) in the refineries at Montpellier.

The taſte of tartar is acid and vinous. One ounce of water, at the temperature of ten degrees above 0 of Reaumur, diſſolves no more than ten grains, according to Chaptal. Others however affirm, that it takes up near twice that quantity. Boiling water diſſolves more, but it falls down in cryſtals by cooling.

Tartar is purified from an abundant extractive principle, by proceſſes which are executed at Montpellier and at Venice.

The following is the proceſs uſed at Montpellier: The tartar is diſſolved in water, and ſuffered to cryſtallize by cooling. The cryſtals are then boiled in another veſſel, with the addition of five or ſix pounds of the white argillaceous earth of Murviel to each quintal of the ſalt. After this boiling with the earth, a very white ſalt is obtained by evaporation, which is known by the name of cream of tartar, or the acidulous tartrite of pot-aſh, according to the new Nomenclature.

M. Deſmaretz has informed us (Journal de Phyſ. 1771) that the proceſs uſed at Venice conſiſts, 1. in drying the tartar in iron boilers; 2. pounding it, and diſſolving it in hot water, which by cooling affords purer cryſtals; 3. re-diſſolving theſe cryſtals in water, and clarifying the ſolution by whites of eggs and aſhes.

The proceſs of Montpellier is preferable to that of Venice. The addition of the aſhes introduces a foreign ſalt, which alters the purity of the product. See Acid of Tartar.

TERRAS. See Tarras.

TERRE VERTE. This is uſed as a pigment, and contains iron in ſome unknown ſtate, mixed with clay, and ſometimes with chalk and pyrites; alum and ſelenite are alſo accidentally found with it. It is difficultly ſoluble in acids, is not magnetic before calcination, and becomes of a coffee colour when heated. It is ſaid to afford about 40 per cent. of iron.

THERMOMETER. In the preſent cultivated ſtate of philoſophical knowledge, it can hardly be ſuppoſed that the reader has not ſeen a thermometer. Minute deſcription is therefore unneceſſary. But as the accurate conſtruction and ſubſequent improvement of this inſtrument muſt greatly depend on the knowledge which thoſe who uſe it may poſſeſs of the method of making it; and as we have no perfect account of this, there can be no doubt but a ſhort relation of the whole proceſs, from experimental knowledge, will be acceptable.

The tubes may be had at the glaſs-houſe; and the firſt care of the artiſt muſt conſiſt in examining if their cavities be equal or cylindrical throughout. This is done by immerſing one end into mercury, and withdrawing it, after cloſing the other end with the finger. By this means a ſmall quantity of mercury will enter the tube, which will occupy a longer ſpace the deeper the tube is immerſed. Lay the tube horizontally upon a graduated rule, and obſerve the length of the mercurial column in different parts of the tube, to which it may be made to run by inclining it more or leſs. If the length continues invariably the ſame, it is a proof that the tube is uniformly cylindrical; but if otherwiſe, the diameter varies, and the tube cannot be uſed to make a good thermometer, unleſs the graduations in the different parts of the tube be lengthened or ſhortened, in proportion to the meaſures of the mercurial column.

Direct the flame of a large candle, a watch-maker's lamp, or, which is cleanlieſt and beſt of all, a lamp with ſpirits of wine, upon one end of the glaſs tube, by means of the blow-pipe. The extremity will ſoon become red hot, and in a ſtate of imperfect fuſion. Remove the tube from the flame, and blow into its other end, and the heated part will be inflated ſo as to form a bulb. This laſt inflation is the moſt difficult and laborious part of the buſineſs; but it may be performed with great eaſe and advantage, by previouſly faſtening the neck of one of the ſmall bottles of elaſtic gum, or India rubber, about the end of the tube; which, when the other end is ignited, may be preſſed by the hand, ſo as to blow the bulb very commodiouſly, and without the introduction of any moiſt air.

Immerſe the open end of the thermometer tube into ſome very clean dry mercury that has been boiled, and warm the bulb with a candle; part of the air will be immediately heard ruſhing through the mercury; withdraw the candle, and as the bulb cools the mercury will riſe in the tube. This will be facilitated by holding the tube as near an horizontal poſition as can be done, without raiſing its lower end above the ſurface of the mercury. In this way the bulb will be nearly half filled. Without altering the poſition of the apparatus, move the whole ſo that the bulb may be held over a candle. A ſmall candle newly ſnuffed is beſt, becauſe of the ſteadineſs of its flame; and it will be neceſſary to wrap a piece of paper round the tube, to defend the finger and thumb from its heat. The mercury will ſoon boil, and moſt of the remaining air will be heard eſcaping from the bulb. As ſoon as this eſcape has ceaſed, remove the bulb from the candle, and it will be ſuddenly filled with mercury from the veſſel.

Take the thermometer thus filled out of the mercury, and wrap round its open end a piece of thin paper, in ſuch a manner as to leave a cavity beyond the tube, at leaſt ſufficient to hold as much mercury as the bulb contains; ſecure this by wrapping it tight with packthread about the tube; then put a drop of mercury into the proper cavity, and apply the bulb again over the ſnuffed candle, holding the tube upright between the finger and thumb, or a pair of ſmall pincers, at the part wrapped with paper and packthread; the mercury will ſoon boil, and about half the contents of the bulb will ruſh violently up the tube into the paper. Remove the bulb from the candle, and the mercury will ſuddenly return; then boil it again, and repeat the operation till the ſpeedy boiling of the mercury, when placed over the candle, and the diminiſhed noiſe and agitation, ſhew that the whole has been well heated, and deprived of the air or moiſture which might have adhered to it.

The operation of boiling will fail, if the mercury or the inſide of the bulb be moiſt; for in this caſe the bulb is uſually burſt by the mercurial vapour; the exploſion however is not dangerous: it is very likely to happen with bulbs blown by the mouth, unleſs they be kept ſome weeks in a dry place before they are filled. The ſame danger makes it prudent not to boil the mercury ſtrongly the firſt or ſecond time; and it is likewiſe of importance to keep the bulb clear of the flame, as the contact of this laſt againſt the empty part of the bulb would melt it, and a hole would be immediately made by the excluded vapour.

After the boiling is completed, plunge the bulb into cold water whoſe temperature is known. Melting ice or ſnow (or ſnow and water) always has the temperature of 32° of Fahrenheit's ſcale. Then take off the paper, and put the bulb into the hand, and afterwards into the mouth; this heating will cauſe ſome of the mercury to drop out of the tube. Cool it again to 32°, by immerſing it in the cold water, and mark where the mercury ſtands. The diſtance between this ſtation and the top of the tube meaſures the interval between freezing and blood heat, or 32 and 95, which makes 63 degrees; and will conſequently ſhew whether the degrees will be large or ſmall, and what extent the ſcale is capable of; that is to ſay, it will ſhew whether the bulb is of the proper ſize. This laſt, ſuppoſing the judgment of the operator not ſufficient to proportion the bulb nearly to the tube and the intended ſcale, might however have been more conveniently aſcertained after the firſt filling, before the boiling had been undertaken.

When the number of degrees to which the length of the tube will extend is thus known, the operator muſt ſettle whereabouts he will have the freezing point, which may be nearer or farther from the bulb, accordingly as he intends the inſtrument to be uſed, more particularly to aſcertain great degrees of heat or of cold. At this ſtage of the buſineſs, likewiſe, he may heat the upper part of the tube with the blow-pipe, and draw it out to a fine capillary tube ready for ſealing. The bulb muſt then be heated in the candle, till a few particles of mercury have fallen off the top of the tube; and notice muſt then be taken how much nearer the freezing point is to the bulb than before, which may be done by immerſing it in the melting ſnow as before. If it be not as low as deſired, the heating muſt be repeated, carefully obſerving not to throw out too much mercury at a time. When the due quantity of mercury is thus adjuſted, two candles muſt be prepared, the one to heat the bulb, and the other to cloſe the tube. The blow-pipe being in readineſs, the upper part of the tube near the flame of one candle, and the bulb near the flame of the other, the mercury will riſe, and at laſt begin to form a globule at the point of the capillary tube. At this inſtant the bulb muſt be withdrawn from the lower candle, at the ſame time that the flame of the upper is directed by the blow-pipe upon the point of the tube. This laſt will be immediately ignited, and will cloſe by the melting of its parts, before the mercury has perceptibly ſubſided. When the mercury has fallen, this cloſure may be rendered more ſecure from accidental breaking, by fuſing the whole point of the tube till it becomes round.

If this buſineſs be properly done, the mercury in the inſtrument thus filled will run backwards and forwards in the tube, immediately upon inverting its ſituation.

In the original graduation of thermometers, two fixed points of temperature are neceſſary. Theſe are the freezing point of water, or temperature of ice or ſnow, at the inſtant of formation, or rather when it is juſt beginning to liquefy; and the boiling point of water, or temperature at which, under a known preſſure, it is plentifully converted into ſteam. For the ſettling the freezing point, nothing more is neceſſary than to immerſe the thermometer ſo deep in melting ſnow or ice, as that the mercury may be barely viſible above its ſurface, and carefully mark the place at which it ſtands. The boiling point is not quite ſo eaſily aſcertained; crude, hard, or ſaline waters acquire a greater heat in boiling than ſuch as are purer; and the ſame water will acquire a greater heat under a greater preſſure. For this laſt reaſon, the boiling point ſhould be fixed according to the deciſion of the committee of the Royal Society; namely, when the barometer ſtands at 29,8 inches. The beſt method is to provide a veſſel ſomewhat longer than the thermometer, with a cover, and two holes in it; one about an inch in diameter, for the ſteam to eſcape; and the other ſmaller, for the thermometer tube to be faſtened in it. When this is uſed, the thermometer muſt be faſtened in the cover, ſo that the eſtimated place of the boiling point may be juſt above the hole. Water muſt be put in the veſſel, not ſufficient to touch the bulb of the thermometer when the cover ſhall be put on. The veſſel muſt then be covered, a thin plate of metal laid on the ſteam-hole, and the water made to boil by heat applied to the bottom only. The thermometer will be then ſurrounded with ſteam, which will raiſe its temperature to the boiling point; and this point muſt be carefully marked on the tube. The following method may be more convenient to thoſe who are not provided with ſuch a veſſel: Wrap ſeveral folds of linen rags or flannel round the tube, nearly as high as the ſuppoſed boiling point; hold the ball of the thermometer in the aſcending current of boiling rain-water, about two or three inches below the ſurface; pour boiling water on the rags three or four times, waiting a few ſeconds between each time; and wait ſome ſeconds after the laſt time of pouring on water, in order that the water may recover its full ſtrength of boiling, which is conſiderably checked by the pouring on the rags. The place where the mercury ſtands is the boiling-water point.

Notwithſtanding the accurate adjuſtment of the fixed points of a thermometer, yet if the tube be not truly cylindrical, or if the diviſions be not adjuſted to the inequalities of its diameter, the errors at the middle, between the two fixed points, may amount to more than a whole degree. A ſmall error in the ſtanding of thermometers may be occaſioned by the varying preſſure of the atmoſphere, which alters the capacity of the glaſs; but it never amounts to ſo much as the tenth part of a degree. Spherical bulbs are leaſt ſubject to this.

Thermometers which from the great length of their degrees, or for any other reaſon, are made to take in but a ſmall part of the interval between the two fixed points, are uſually graduated by compariſon with a ſtandard thermometer.

The very careful boiling of the mercury, as above deſcribed, is abſolutely neceſſary for ſuch thermometers as are to be ſealed when full; for if there were any air or moiſture left in the bulb, it would prevent the mercury in the tube from deſcending into the bulb, ſo that the tube would continue always full. Theſe thermometers are undoubtedly the beſt; but the vacuum above the mercury does not ſeem to be an indiſpenſable requiſite. If a clean dry tube be filled with pure boiled mercury, and a ſmall bulb be left at the top of the tube, to contain common air, in order that its expanſion or condenſation, produced by the change in the mercurial ſurface, may be inconſiderable; there will be few practical objections againſt ſuch a thermometer; more eſpecially if it be a ſecondary inſtrument, graduated by means of a ſtandard. There are ſome thermometers made with tubes ſo very ſmall, and bulbs ſo large in proportion to them, that they will not admit of boiling the mercury in them, but are filled with boiled mercury by means of a condenſer. Theſe are neceſſarily of the kind here mentioned.

The thermometers moſt in uſe at preſent are Fahrenheit's, Reaumur's, and Celſius's. In Fahrenheit's ſcale the number of degrees between the freezing and boiling water point is 180; the freezing point being at 32°, and the boiling point at 212°, both above 0°, or the part from which the degrees are reckoned both ways. In Reaumur's ſcale, the number of degrees between theſe two points is 80, and the freezing point is called 0°, from which the degrees are reckoned both ways. In Celſius's thermometer, the interval is divided into 100°, and the freezing point is called 0°, as in Reaumur's. To reduce theſe ſcales to each other, it muſt be obſerved, that one degree of Fahrenheit's is equal to $\frac{4}{9}$ of a degree of Reaumur, and to $\frac{5}{9}$ of a degree of Celſius. Therefore, if the number of degrees of Fahrenheit, reckoned above or below the freezing point, be multiplied by 4, and divided by 9, the quotient will be the correſponding number on Reaumur's ſcale. Or if the multiplier 5 and the diviſor 9 be uſed, the quotient will give the degrees of Celſius's ſcale. And, contrariwiſe, if any number of degrees, either of Reaumur or Celſius, be multiplied by 9, and divided by 4 if of Reaumur, or by 5 if of Celſius, the quotient will give the degrees of Fahrenheit, reckoned either above or below the freezing point, as the caſe may be.

TIN is a metal of a yellowiſh-white colour, conſiderably harder than lead, ſcarcely at all ſonorous, very malleable, though not very tenacious. Wires cannot be made of it; but under the hammer it is extended into leaves, called tin foil, which are about one-thouſandth of an inch thick, and might eaſily be beaten to leſs than half that thickneſs, if the purpoſes of trade required it. The proceſs for making tin foil conſiſts ſimply in hammering out a number of plates of this metal, laid together upon a ſmooth block, or plate of iron. The ſmalleſt ſheets are the thinneſt. Its ſpecific gravity is leſs than that of any other malleable metal. Long before ignition, it melts at about the 410th degree of Fahrenheit's thermometer, and by a continuance of the heat it is ſlowly converted into a white powder by calcination. Like lead, it is brittle when heated almoſt to fuſion, and exhibits a grained or fibrous texture, if broken by the blow of a hammer; it may alſo be granulated by agitation at the time of its tranſition from the fluid to the ſolid ſtate. The calx of tin reſiſts fuſion more ſtrongly than that of any other metal; from which property, it is uſeful to form an opake white enamel when mixed with pure glaſs in fuſion. The brightneſs of its ſurface when ſcraped, ſoon goes off by expoſure to the air; but it is not ſubject to ruſt or corroſion by expoſure to the weather.

Concentrated vitriolic acid, aſſiſted by heat, diſſolves half its weight of tin, at the ſame time that vitriolic acid air eſcapes in great plenty. By the addition of water a calx of tin is precipitated. Vitriolic acid, ſlightly diluted, likewiſe acts upon this metal; but if much water be preſent, the ſolution does not take place. In the vitriolic ſolution of tin there is an actual formation, or extrication of ſulphur, which renders the fluid of a brown colour whilſt it continues heated, but ſubſides by cooling. The tin is likewiſe precipitated in the form of a white calx by a continuance of the heat, or by long ſtanding without heat. This ſolution affords needle-formed cryſtals by cooling.

Nitrous acid and tin combine together very rapidly, without the aſſiſtance of heat. Moſt of the metal falls down in the form of a white calx, extremely difficult of reduction; and the ſmall portion of tin which remains ſuſpended, does not afford cryſtals, but falls down, for the moſt part, upon the application of heat, to inſpiſſate the fluid. The ſtrong action of the nitrous acid upon tin produces a ſingular phenomenon, which is happily accounted for by the modern diſcoveries in chemiſtry. M. de Morveau* has obſerved, that, in a ſolution of tin by the nitrous acid, no elaſtic fluid was diſengaged, but that volatile alkali was formed. This alkali muſt have been produced by the phlogiſticated air of that part of the nitrous acid which was employed in affording pure air to calcine the tin. The phlogiſticated air muſt therefore have combined with inflammable air: but whether this inflammable air was afforded by a decompoſition of the water of the menſtruum, or whether it came from the phlogiſton of the tin, is a queſtion that muſt remain undetermined, until deciſive experiments have been made for the eſtabliſhment of one or the other of the two theories, which at preſent divide the chemical world.

The marine acid diſſolves tin very readily, at the ſame time that it becomes of a darker colour, and ceaſes to emit fumes. A ſlight effervefcence takes place with the diſengagement of a fetid inflammable gas. Marine acid ſuſpends half its weight of tin, and does not let it fall by repoſe. It affords permanent cryſtals by evaporation. If the tin contain arſenic, it remains undiſſolved at the bottom of the fluid.

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* Kirwan on Phlogiſton, 2d edition, p. 234.

Dephlogiſticated marine acid diſſolves tin very readily, and without ſenſible effervefcence. The ſolution itſelf does not appear to differ from the foregoing.

Aqua regia, conſiſting of two parts nitrous and one marine acid, combines with tin with effervefcence, and the developement of much heat. In order to obtain a permanent ſolution of tin in this acid, it is neceſſary to add the metal by ſmall portions at a time; ſo that the one portion may be entirely diſſolved before the next piece is added. Aqua regia, in this manner, diſſolves half its weight of tin. The ſolution is of a reddiſh brown, and in many inſtances aſſumes the form of a concrete gelatinous ſubſtance. The addition of water ſometimes produces the concrete form in this ſolution, which is then of an opal colour, on account of the calx of tin diffuſed through its ſubſtance. The uncertainty attending theſe experiments, with the ſolution of tin in aqua regia, ſeems to depend upon the want of a ſufficient degree of accuracy in aſcertaining the ſpecific gravities of the two acids which are mixed, the quantities of each, and of the tin, together with that of the water added. It is probable that the ſpontaneous aſſumption of the concrete ſtate depends upon water imbibed from the atmoſphere. The ſolution of tin in aqua regia is uſed by degrees to heighten the colours of cochineal, gum lac, and ſome other red tinctures, from crimſon to a bright ſcarlet, in the dying of woollens.

M. Hermſtædt has ſucceeded in the actual acidification of this metal, by treating it with the marine and nitrous acids. He diſſolves pure tin in pure marine acid, and boils this ſolution with nitrous acid (diſtilled from mangaueſe), until the red vapours ceaſe to appear. The fluid, which is then limpid, is expoſed to diſtillation, until the whole of the marine and nitrous acids have been diſſipated. The white remaining maſs is ſoluble in three parts of water, and is the acid of tin. A red heat converts this matter into a yellow tranſparent ſubſtance, neither acid nor ſoluble in water; but it regains both properties by a few weeks expoſure to the air*.

The acetous acid ſcarcely acts upon tin. The operation of other acids upon this metal has been little enquired into.

When equal parts of an amalgam of tin and mercury, and of corroſive ſublimate, are triturated together, and the mixture expoſed to diſtillation in a retort, by a very gentle heat; a colourleſs fluid firſt comes over, which is followed by a thick white fume, which becomes condenſed into a tranſparent liquor, called the fuming liquor of Libavius, on account of the copious fumes it emits when the veſſel that contains it is opened. On account of the conſiderable volatility of this liquid, it riſes partly in the form of flowers to the top of the bottle in which it is put; ſo that, in the courſe of ſeveral months, it becomes entirely cloſed. The compoſition and effects of this liquid were but imperfectly known until lately, when Mr. Adet made ſeveral ingenious experiments upon it. By expoſing this liquid under receivers containing dry air, over mercury, he found that the volatile fluid aroſe, and lined the veſſel with cryſtals, when water was preſent, though very few cryſtals were formed when the air was as dry as it could be made. He obſerved likewiſe, that when water was added to the fuming liquor of Libavius, it became ſolid, and ceaſed to emit fumes. A preciſe quantity of water is required to produce this effect in the moſt perfect manner. If the quantity of water be too ſmall, the liquor retains more or leſs of its diſpoſition for the fluid ſtate; and if it be too conſiderable, the fluidity of the water prevails. By ſeveral trials he found, that the due proportion of water to be added to the fuming liquor of Libavius was 7 to 22. A kind of ebullition, or eſcape of bubbles, was produced during the combination; which, on examination, was found to ariſe from the eſcape of the air previouſly contained in the fluid water. He found likewiſe, that this concrete ſubſtance, when rendered fluid by an increaſe of temperature, was capable of diſſolving more tin, without the diſengagement of inflammable air. After the concrete ſubſtance was ſaturated with tin, it could no longer be ſublimed, but might be made to undergo a red heat, during which time there was an eſcape of vapours, conſiſting of tin combined with the marine acid; and after a ſtrong heat, the reſidue was a white calx of tin. It appeared therefore, that the liquor of Libavius, rendered concrete by water, and ſaturated with tin, reſembles in its properties the common ſolution of tin in the marine acid.

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* Journal de Phyſ. xxxv. 391. Nov. 1789.

From theſe circumſtances Mr. Adet concludes, that the tin, by ſtronger affinity, combines with the aerated or dephlogiſticated marine acid of the corroſive ſublimate with which it is heated; that this combination contains no water; and that, as it abounds with a ſubſtance of ſuch extreme volatility as that aerated acid, its freezing point is very low, inſomuch that it is habitually fluid; that the addition of water, in a due proportion, alters the freezing point, and renders it concrete at a common temperature; and laſtly, that the ſtate of the marine acid in this ſubſtance is that which is called aerated, or dephlogiſticated; which is proved, as well from the experiments which aſcertain that ſtate in corroſive ſublimate, as from ſimilar experiments with the fuming liquor, which, as has been obſerved, is capable of diſſolving more tin without diſengaging inflammable air; the fuming liquor of Libavius has therefore the ſame relation to the common ſolution of tin as corroſive ſublimate has to calomel*.

The reſidue, after the diſtillation by which the fuming liquor of Libavius is produced, conſiſts of tin combined with the marine acid, calomel, and running mercury, which ſublime into the roof and neck of the retort; and at the bottom is found an amalgam of mercury and tin, covered with a ſaline combination of marine acid with tin, and ſuch other metals as the tin may have been adulterated with. Much information may be derived from the foregoing experiments of Mr. Adet reſpecting the phenomena produced when tin is diſſolved in aqua regia.

Earthy ſubſtances do not appear to affect this metal in the dry way. It detonates very rapidly with nitre, and becomes converted into a calx, which partly combines with the alkali. All the vitriolic ſalts are decompoſed by tin. The tin becomes calcined, and the vitriolic acid converted into ſulphur, either by the phlogiſton of the metal, according to the ancient theory, or by the ſubtraction of its vital air, according to the modern theory. This ſulphur appears to combine with the alkali, or earth of the ſalt, with which it forms an hepar that diſſolves part of the calx.

Sal ammoniac is very readily decompoſed by tin. Alkaline and inflammable air are diſengaged, and a concrete marine ſalt remains behind, which in ſome meaſure reſembles the fuming liquor of Libavius. The volatile alkali, or alkaline air, which eſcapes, is diſengaged by virtue of the ſuperior affinity of the calx of tin with the marine acid, at the temperature of the experiment. The inflammable air, which likewiſe flies off, is a conſequence of the calcination of the tin, or the decompoſition of the water, according to the theory which may be applied in the explanation. Notwithſtanding the facility with which this metal decompoſes ſal ammoniac, there is an inconvenience reſulting from its uſe which depends on the great fuſibility of this metal; in conſequence of which, it cannot be intimately mixed with the ſal ammoniac, but remains at the bottom of the veſſel in the fluid ſtate, while part of the ſal ammoniac eludes its action, and is ſublimed entire.

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* Annales de Chimie, i. 1, &c.

If the cryſtals of the ſaline combination of copper with the nitrous acid be groſsly powdered, moiſtened, and rolled up in tin-foil, the ſalt deliqueſces, nitrous fumes are emitted, the maſs becomes hot, and ſuddenly takes fire. In this experiment * the rapid tranſition of the nitrous acid to the tin, is ſuppoſed to produce or develope heat enough to ſet fire to the nitrous ſalts; but by what particular changes of capacity has not been ſhewn.

If ſulphur, in powder, be added to about five times its weight of melted tin, the two ſubſtances combine, and form a black compound, which takes fire, and is much leſs eaſily fuſed than tin itſelf. The maſs is brittle, and of a needled texture.

The combination of tin and ſulphur forms a compound called *aurum muſivum*, which ſee.

When tin is heated with phoſphoric acid and charcoal, the metal appears to be very little changed. A combination, however, ſeems to take place; for the phoſphorus burns on the ſurface of the metal when heated by the blow-pipe.

Tin unites with biſmuth by fuſion, and becomes harder and more brittle in proportion to the quantity of ſemi-metal added. With nickel it forms a white brilliant maſs. It cannot eaſily be united in the direct way with arſenic, on account of the volatility of this ſemi-metal; but by heating it with the combination of the arſenical acid and vegetable alkali, the ſalt is partly decompoſed; and the tin combining with the acid becomes converted into a brilliant brittle compound, of a plated texture. It is thought that all tin contains arſenic; and that the crackling noiſe which is heard upon bending pieces of tin, is produced by this impurity. Cobalt unites with tin by fuſion; and forms a grained mixture of a colour ſlightly inclining to violet. Zinc unites very well with tin, increaſing its hardneſs, and diminiſhing its ductility, in proportion as the quantity of zinc is greater. This is one of the principal additions uſed in making pewter, which conſiſts for the moſt part of tin. The beſt pewter does not contain above one-twentieth part of admixture, which conſiſts of zinc, copper, biſmuth, or ſuch other metallic ſubſtances as experience has ſhewn to be moſt conducive to the improvement of its hardneſs and colour. The inferior ſorts of pewter, more eſpecially thoſe uſed abroad, contain much lead, have a blueiſh colour, and are ſoft. The tin uſually met with in commerce in this country, has no admixture to impair its purity, except ſuch as may accidentally elude the workmen at the mines. But the tin met with in foreign countries is ſo much debaſed by the dealers in that article, eſpecially the Dutch, that pewter and tin are conſidered abroad as the ſame ſubſtance. Regulus of antimony forms a very brittle, hard mixture with tin; the ſpecific gravity of which is leſs than would have been deduced by computation from the ſpecific gravities and quantities of each, ſeparately taken. Wolfram fuſed with twice its weight of tin affords a brown ſpungy calx, which is ſomewhat ductile.

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* Of Dr. Higgins, Philoſ. Tranſ. lxiii. p. 137.

Tin is ſcarcely ever found native. Native tin may be analyſed in the moiſt way, by the application of nitrous acid, which calcines the tin, and diſſolves the other metals it may contain. One hundred and forty grains of the waſhed and dried calx are equivalent to one hundred grains of metallic tin. The metallic admixtures may be ſeparated from the nitrous acid, by methods adapted to their reſpective properties; which may be eaſily gathered from what has been obſerved in the humid analyſis of the metals before treated of.

The calciform ores of tin are—tin ſpar, which is generally of a whitiſh or gray colour, ſometimes greeniſh or yellowiſh, ſemi-tranſparent, and cryſtallized in a pyramidal form, or irregularly—opake brown or black tin ore, cryſtallized and embodied in quartz, fluor, or mica, or mixed with white and yellow pyrites; theſe ores contain a mixture of iron—the reddiſh-yellow, or garnet ore, which contains more of iron than tin—and the tin-ſtone, vulgarly called load-ſtones, which contain ſtill leſs tin. See Ores of Tin.

It was formerly ſuppoſed that tin was frequently mineralized by arſenic; but it is now admitted, that the arſenic which may be contained in tin is afforded by the matrix. The ſcarcity of ſulphureous tin ores was likewiſe conſidered, till lately, as a very ſingular fact, on account of the facility with which that ſubſtance unites to tin: ſuch combinations however have ſince been found. The native aurum muſivum, from Siberia, is of this kind: and a very conſiderable vein of tin in combination with ſulphur, and an admixture of copper and iron, has been found in Cornwall*. The analyſis of tin ores in the humid way is an object of ſome difficulty; becauſe they are not acted upon effectually either by the vitriolic, nitrous, or marine acids, or by an aqua regia. The method of Bergman is as follows: The ore muſt be reduced to a very ſubtle powder by levigation and elutriation. This laſt proceſs conſiſts in agitating any powder in water, which is heavy enough to ſink in that fluid. The particles will be reſiſted in their deſcent, according to the ſurfaces they oppoſe againſt the fluid. It is ſcarcely neceſſary to obſerve, that a larger body preſents a leſs ſurface to be reſiſted, than the ſame body would oppoſe if it were divided into parts. For this reaſon, when a powder conſiſting of particles of the ſame denſity, but different magnitudes, is agitated in a ſlighter fluid, the largeſt pieces come firſt to the bottom: and hence the method of elutriation enables us to aſſort the various particles of a powder according to their magnitudes, by firſt agitating the fluid, and ſucceſſively decanting it into different veſſels. Thus, for example, if the water be decanted five ſeconds after the agitation, it will leave a powder behind it; if it be again decanted at the end of five ſeconds more, the ſecond veſſel will contain a much finer powder than the foregoing; and, by a third decantation, a ſtill more ſubtile powder will be obtained. This is the method applied in the preparation of the white calx of tin, called putty, and uſed for poliſhing fine metallic ſpeculums, and the object lenſes of teleſcopes; and in this way the tin ore to be analyſed may be reduced to a very ſubtile powder, by levigating and again waſhing the coarſe reſidue which ſubſides in the firſt veſſel. It may be obſerved, that the ſucceſſive decantations are unneceſſary where the very fineſt powder only is wanting; becauſe this may be as well obtained by ſuffering the water to ſtand a ſufficient time before it is decanted off at firſt. To the very ſubtile powder of tin ore, thus afforded, a quantity of concentrated vitriolic acid muſt be added, and kept in a ſtrong digeſting heat for ſeveral hours. A ſmall portion of concentrated marine acid muſt be poured into this when cold. A ſtrong efferveſcence takes place with conſiderable heat, and the eſcape of marine acid air, which has been deprived of its water by the vitriolic acid. After the expiration of an hour or two, ſome water muſt be added, and the clear liquor decanted. The ſame operation muſt be repeated with the reſiduum, until the acids can diſſolve no more: and nothing will then remain but the ſtony matrix. The ſolution, when precipitated by means of mild alkali, will afford 100 grains of metallic tin for each 132 grains of precipitate, when waſhed and dried. If the precipitate do not conſiſt of pure tin, but contain copper or iron, it muſt be calcined for an hour in a red heat; then digeſted in nitrous acid, which will take up the copper; and afterwards in marine acid, which will diſſolve the iron.

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* See Magellan's Cronſtedt, p. 637. The contents of one ſpecimen were 30 parts ſulphur, 41 tin, 43 copper, 2 iron, and 3 ſtony matrix.

In the dry way, after pulverization, and ſeparation of the ſtony matter by waſhing, the tin ores may be haſtily fuſed with twice their weight of a mixture of pitch and calcined borax, in a crucible lined with charcoal, and covered; or the ore may be mixed with twice its weight of tartar, one part of black flux, and half a part of reſin. This mixture being then divided into three parts, each part muſt be ſucceſſively projected into a crucible ignited to whiteneſs, which muſt be immediately covered as ſoon as the portion thrown in ceaſes to flame.

The operation of reducing tin ores in the large way, is conducted upon ſimilar principles. When impure, they are cleanſed from foreign admixtures, by ſorting, pounding, and waſhing. A ſlight previous roaſting renders the ſtony parts more friable; and when arſenic is contained in the matrix, it is driven off by a ſtrong heat, continued for a ſhort time; the ore being frequently ſtirred, to prevent its running together by fuſion. In the ſmelting of the ore, care is taken to add a larger quantity of fuel than is uſual in the reviving of other metals; and to avoid a greater heat than is neceſſary to reduce the ore, in order that the loſs by calcination may be prevented as much as poſſible. See Ores, p. 609.

Tin is a metal which, as far as our preſent information extends, is not very much diffuſed. It is found in Bohemia and Saxony, and on the iſland of Malacca in the Eaſt Indies. But the largeſt quantities, at leaſt for the European conſumption, are found in England; particularly in the county of Cornwall. This iſland has been famous for its tin mines from the remoteſt periods of hiſtory; and would not, probably, have been frequented by the ancient Phœnician navigators, if they had not been attracted hither by the great plenty of tin with which it abounds. Several etymologiſts have endeavoured to ſhew, that the name of Britain is derived from a word common to the Syrian and Chaldæan languages, denoting tin; but on this no great ſtreſs can be laid.

The uſes of tin are very numerous, and ſo well known, that they ſcarcely need be pointed out. Several of them have been already mentioned. The tinning of iron and copper, the ſilvering of looking-glaſſes, and the fabrication of a great variety of veſſels and utenſils for domeſtic and other uſes, are among the advantages derived from this metal.

TINCAL. Crude borax, as it is imported from the Eaſt Indies in yellow greaſy cryſtals, is called tincal. Its origin was long unknown, or related in ſuch a manner by travellers, that philoſophical enquiries ſeemed to have given them little credit. For ſeveral authentic accounts, ſee the article Borax. Mr. Hoefer, who aſcertained the exiſtence of the acid of borax in certain lakes in Tuſcany, publiſhed an expreſs treatiſe on this ſubject in the year 1778, which I have not ſeen, but of which a ſhort extract is given in the Journal de Phyſique for June 1779. Several of his narratives reſpecting its origin agree with thoſe inſerted in the article laſt referred to. He mentions as a fact, that the Thibetians draw off the waters of certain lakes, for the purpoſe of obtaining the cryſtals which are found among the mud at the bottom, and that this mud emits dangerous and very cauſtic exhalations.

The method of refining borax in Holland, according to him, is as follows: One hundred pounds of crude borax from India afford eighty pounds of the refined ſort. The impure ſalt is very difficult of ſolution. Double the weight of hot water is added to a given weight of the ſalt, and afterwards decanted off. A like quantity of hot water is again added, and theſe equal additions of water and decantations are repeatedly made for eight or ten times before the whole of the ſaline matter is extracted. By this means eight or ten cryſtallizations of borax are obtained, which differ from each other in colour, figure, tranſparence, and weight. After the crude borax is thus deprived of the foreign earthy and ſtony matters, it is diſpoſed for ſolution by macerating it in its own weight of hot water during eight days. I ſuppoſe of courſe that water is to be added to ſupply the loſs by evaporation during this time. Each ſolution is then poured boiling hot through a woollen ſtrainer ſupported on braſs wire work. The firſt ſolutions are made ſlowly, and are reddiſh. The latter are ſcarcely coloured, and require leſs time. The hot liquor is then poured very hot into a leaden veſſel in the form of a very large crucible, in which it is evaporated by a ſlow fire. It is then ſet aſide, ſurrounded with a large quantity of finely minced ſtraw; a wooden cover faced with lead is placed on it, and the whole is covered up with mats and cloths. Theſe precautions keep the fluid hot a long time, and facilitate the ſeparation of foreign matters as well as the regularity of the cryſtallization. This laſt operation continues twenty days, after which the borax is taken out in fine cryſtals for the market.

TINCTURES of vegetable and animal substances. Many medicinal preparations are called tinctures, becauſe they are made by digeſting certain vegetable and animal ſubſtances in ſpirit of wine, to which they communicate different colours according to their nature.

Some of theſe tinctures are made with one vegetable or animal ſubſtance only. Theſe are called ſimple tinctures, and they are diſtinguiſhed by the name of the vegetable or animal matter employed; ſuch are the tinctures of myrrh, of aloes, of ſaffron, of caſtor, and many others.

Others contain a greater or leſs number of different vegetable and animal ſubſtances, which are digeſted in ſpirit of wine, according to the ſeveral receipts. Theſe have the general name of compound tinctures, and are alſo diſtinguiſhed by the names of their particular authors and qualities.

Theſe ſeveral tinctures are rather objects of pharmacy than of chemiſtry. Macquer makes the following general obſervations upon them:

Firſt, as vegetables and animals are compoſed of ſeveral principles which are not all ſoluble, or not equally ſoluble in ſpirit of wine, we cannot conſider ſpirituous tinctures as complete extracts of the vegetable and animal ſubſtances employed in their preparation.

Secondly, the principles of thoſe ſubſtances upon which ſpirit of wine can act, are volatile eſſential oils, and others of the ſame nature; reſins, properly ſo called; any oils that are in a ſaponaceous ſtate, and ſoluble in water by means of ſome ſaline matter; acids; and laſtly, ſeveral kinds of neutral ſalts. And the principles which ſpirit of wine cannot diſſolve directly, are ſweet oils and oily concretions that are not volatile nor ſaline; ſubſtances purely gelatinous and gummy; earthy matters not ſaline, nor ſoluble in water; and laſtly, many neutral ſalts, which are inſoluble in ſpirit of wine, the various kinds of which have not yet been determined.

Thirdly, many of the vegetable and animal principles that are eſſentially inſoluble in ſpirit of wine, particularly gums, jellies, and neutral ſalts, are ſoluble in water.

Fourthly, from the laſt obſervation we may perceive, that tinctures drawn from the ſame vegetable or animal ſubſtance muſt differ conſiderably, according to the ſtate of dryneſs of theſe ſubſtances, and the dephlegmation of ſpirit of wine employed. For a tincture made from moiſt plants, and with a weak ſpirit of wine, muſt contain ſome gummy and ſaline principles, which could not be contained in a tincture made with the plants perfectly dried and a ſpirit of wine perfectly rectified.

Fifthly, as many chemical experiments ſhew that ſubſtances naturally inſoluble in any certain menſtruum, may be rendered ſoluble in that menſtruum by ſome other intermediate ſubſtance; and as amongſt the vegetable and animal principles, ſome ſuch intermediate ſubſtances may exiſt; it cannot therefore be affirmed, that ſpirituous tinctures contain no other of theſe principles than ſuch as are naturally ſoluble in ſpirit of wine; but it ſeems more probable that they contain other principles. As this ſubject has not been ſufficiently examined, it is impoſſible to ſpeak upon it in any other than a vague and general manner.

TINNING OF COPPER AND OF IRON. Tinning is an operation by which a very thin layer of tin is applied to the ſurface of ſome metals, and eſpecially of copper and of iron. The methods of tinning theſe two metals are different. Copper is tinned after it has been formed into utenſils, and by the copper-ſmiths who form theſe utenſils. The tinning of iron is performed upon thin plates of iron, in particular manufactories in France, England, Germany, and in ſome other places.

The ſeveral operations for tinning of copper and iron are founded, firſt, on the facility with which tin unites with theſe metals, which is ſo great, that when either of theſe metals is tinned, the tin only requires to be melted, and the others on which it is to be applied do not. Nevertheleſs, the tin incorporates with theſe metals, diſſolves in ſome meaſure their ſurface, and forms a kind of alloy, at leaſt when the tinning is well performed.

Secondly, the foundation of all the parts of the operation uſed to make the tinning ſucceed is, that metals cannot perfectly unite with each other but when they are in a metallic ſtate; and that they cannot unite with any earthy matter, not even with their own earth or calces.

Hence the whole art of tinning conſiſts in employing melted tin, the ſurface of which ſhall be very clean, metallic, and not covered with any aſhes or calx of tin, to the ſurface of iron or of copper, which muſt alſo be very clean, and free from all ruſt or calx.

To attain theſe purpoſes the following method is uſed: As the ſurface of copper is continually altered merely by the action of air, the workmen before the tinning of any veſſel ſcrape its ſurface with a ſteel inſtrument till it be clean and bright; then they place the veſſel upon kindled coals, and heat it to a certain degree: as ſoon as it is hot they rub it with pitch; and then apply the melted tin, which they ſpread upon the ſurface of the copper by means of hards, or balls of flax. Pure tin is ſeldom uſed for this purpoſe; but generally two parts of tin are allayed with one part of lead.

The pitch uſed in this operation is quite neceſſary, becauſe the degree of heat given to the copper is ſufficient to calcine its ſurface in ſome meaſure; and this alteration, however ſlight, would prevent the perfect adheſion of the tin. This pitch prevents alſo the ſlight calcination which would happen on the ſurface of the tin, or revives the ſmall particles of calx which are formed during the operation.

When plates of iron are to be tinned, they muſt be perfectly well cleanſed, which is done by ſcouring them with ſand, and ſteeping them ſome time in an acid liquor: then they are to be wiped, and dried quickly and perfectly. Laſtly, they are to be plunged vertically into a veſſel containing melted tin, the ſurface of which is covered with fat and pitch. Theſe fat ſubſtances covering the ſurface of the tin prevent its calcination, by which its adheſion to the iron would be impeded; and alſo render the ſurface of the iron, while it paſſes through them, fitter to receive the tin. By thus plunging plates of iron into melted tin, they are covered over with this metal, or are tinned.

Sal ammoniac is alſo uſed ſuccefsfully in the tinning of iron and copper, and always for the ſame reaſon. The acid of this ſalt perfectly cleans the ſurface of the metals to be tinned; and the oily matter, or perhaps the inflammable air of the alkali contained in ſal ammoniac, prevents the calcination. Thus by heating theſe metals to a certain degree, and rubbing them with ſal ammoniac, the tin may be applied immediately afterwards.

The art of tinning is kept a great ſecret by the workmen, but does not appear to be in any reſpect difficult to an ingenious contriver. Thus iron tacks, which cannot be conveniently tinned in a bath, are eaſily covered with that material by including the nails, with a due proportion of tin and ſal ammoniac, in a ſtone bottle, and agitating them while heating and cooling.

The advantages received from tinning are very conſiderable. As tin is a ſoft and fuſible metal, veſſels formed of it alone would not have ſufficient ſtrength and hardneſs to keep their ſhape in common uſe, and would alſo be liable to be melted with a ſmall heat: but when it is applied to the ſurface of hard and difficultly fuſible metals, as copper and iron, many veſſels may be fabricated which have the advantage of being preſerved by means of the tin from ruſt, to which the copper and iron are very ſubject. It has been nevertheleſs juſtly alleged, that copper veſſels are not perfectly prevented from ruſt or verdigriſe by tinning; and this fault is ſo much more important, as tinned copper veſſels are uſed in the preparation of food. Theſe veſſels, therefore, even when tinned, ought not to be employed for this purpoſe: eſpecially as tin itſelf is ſuſpected of being hurtful to health, ſince Margraaf diſcovered that arſenic is contained in almoſt all tin; and alſo becauſe lead, a moſt hurtful metal, is uſed in tinning. Nevertheleſs, tinned copper veſſels may be uſed for many other purpoſes. Beſides, the tinning of copper and iron veſſels may be improved by attending to the fundamental principles of this art delivered in the preſent article.

M. Malouin has propoſed in his Memoirs on Zinc (Mem. de l'Acad. des Sciences, 1742) to ſubſtitute that ſemi-metal in place of lead and tin, for the tinning of iron and copper veſſels. The greater hardneſs of the zinc, it is thought, would render it leſs liable to be worn; and the dangerous effects of lead and tin would be avoided. But whether it might not be attended with other inconveniences muſt be ſubmitted to further experience.

For the tinning of looking-glaſſes, ſee SILVERING.

The tinning of pins has been the object of a conſiderable ſeries of inveſtigations by Mr. Gadolin. In the Journal de Phyſique for May and June 1789, there is a tranſlation of his Memoir by Dolfuſs, of which the following is an abſtract. It is a generally admitted fact, that copper diſſolved in any acid whatever is always totally precipitated by the addition of tin. The experiment of whitening pins ſhews nevertheleſs that tin is really precipitated in the metallic form by copper, if both be boiled in a ſolution of tartar. Mr. Gadolin, in the preſence of Mr. Gahnn, found that the remaining fluid contained no copper; whence theſe chemiſts concluded, that the precipitation muſt be effected in ſome way different from that of the ordinary elective attraction. He therefore inſtituted the following experiments:

1. A leaf of tin was kept ſome days in a ſolution of half a loth of cream of tartar, after which it was found to have loſt 0,005 loth of its weight. A plate of copper, by digeſtion for ſix hours in the fluid, after the tin was taken out, loſt 0,0006 loth of its weight, but was not viſibly altered, excepting that its ſurface was ſlightly calcined. The ſolution was then boiled with poliſhed iron, and both the tin and the copper were precipitated on the iron. 2. The reſults were nearly the ſame when acid of tartar was uſed inſtead of the cream of tartar. 3. To a ſolution of tin in aqua regia, ſoluble tartar was added: the tin fell down in combination with the acid of tartar. Of this precipitate, firſt edulcorated and dried, half a loaf was boiled with water and a poliſhed copper-plate for three hours. No remarkable change happened to the copper. 4. The laſt experiment was repeated with one tenth of a loth of the precipitate, and 0,07 loth of cryſtallized acid of tartar. The reſult was as before. 5. Tin foil was then added along with the poliſhed copper in the laſt-mentioned ſolution. After three hours boiling the copper became covered with a pellicle of tin, which was rather dull, and had increaſed in weight 0,0002 loth. The tin loſt 0,001 loth. 6. One tenth of a loth of the precipitate N° 3, was boiled for three hours on a plate of copper, with the addition of tin foil. The tin became of a blackiſh yellow dull colour, with the loſs of 0,0009 loth; but the copper was not at all changed. 8. The laſt-mentioned experiment was made, with the addition of half a loth of cream of tartar to the ſolution. The tin loſt 0,0009 loth of its weight; the copper became covered with a very ſlight pellicle, and had loſt 0,0004 of its weight. 9. Half a loth of cream of tartar, diſſolved in water, was boiled with leaves of tin and a plate of poliſhed copper. The copper became covered with a pellicle of tin, and had gained in weight 0,0001 loth. The tin had loſt 0,0004 loth. 10. One ſixth of a loth of cryſtallized acid of tartar was diſſolved in water, and boiled with leaves of tin and poliſhed copper for three hours: the tin loſt 0,0004 loth; but the copper was not changed either in colour or weight. 11. To the laſt-mentioned ſolution a quantity of vegetable alkali was added, ſufficient to ſaturate the tartar. A plate of copper and leaves of tin were again added, and the whole boiled a little. The tin thus added loſt 0,0005 loth of its weight. The copper was covered with a pellicle of tin, but did not acquire any perceptible increaſe of weight. 12. One loth of cream of tartar was diſſolved in water, and ſaturated

with vegetable alkali. In this ſolution leaves of tin and poliſhed copper were boiled for three hours, at the end of which time the copper was not changed, but the tin had loſt 0,0014 of its weight. A few drops of ſolution of the acid of tartar were then added, and the boiling repeated. The copper became covered with tin. 13. Two thirds of a loth of cream of tartar were diſſolved in water, and boiled with a plate of poliſhed copper, the ſurface of which was covered with a ſlight pellicle of tin: the copper had loſt by that means 0,0062 loth of its weight, in the form of a detached ſcoria. One part was diſſolved, and the reſt lay at the bottom of the phial. Into this ſolution a plate of poliſhed copper was put, with leaves of tin. After three hours the tin and the copper were found covered with a black thick cruſt, which might have been ſcaled off. The tin had loſt 0,007 loth of its weight by this operation. But the copper had loſt nothing, and was covered with an unequal tarniſhed film of tin. On thoſe parts from which the black pellicle was removed, a ſlight ſcale of tin might be perceived. 14. Two thirds of a loth of cream of tartar were diſſolved in water, and to this were added 0,005 loth of calx of copper, precipitated from blue vitriol by vegetable alkali. After having boiled in this ſolution a piece of tin in leaves and poliſhed copper for the ſpace of three hours, the tin became covered with an entire cruſt, but detached as in the laſt experiment. After the ſeparation of this cruſt, the tin weighed 0,0071 loth leſs than before. The copper was covered with a blackiſh pellicle, and had gained 0,004 loth of weight. 15. One ſixteenth of a loth of cryſtallized acid of tartar, and 0,0028 loth of precipitated calx of copper. In this ſolution a plate of poliſhed copper and tin in leaves were boiled for three hours. It was then found that the tin, cleared of its black cruſt, had loſt 0,0056 loth. The copper, which was covered with a black pellicle not detached, had gained 0,0004 loth. 16. In a ſolution of one ſixth of a loth of cryſtallized acid of tartar in water, a piece of iron was boiled during half an hour, and loſt 0,002 by ſolution. Into this clear ſolution a piece of poliſhed copper and leaves of tin were put, and boiled for three hours. The copper became covered with a bright pellicle of tin, without any remarkable acquiſition of weight. The tin had loſt 0,0004 loth.

The reaſoning of Mr. Gadolin on theſe experiments is premiſed by two obſervations: 1. That in all calcination of metals, a common ſubſtance unites with and becomes a component part of the calx, which to avoid reference to every theory he calls the calcining matter. 2. That a metal is calcinable in different degrees, and is diſpoſed to combine with a greater portion of calcining matter, or to part with ſome of that which it already holds, accordingly as that quantity is leſs or greater. He then proceeds to infer,

That copper can never ſeparate metallic tin from a ſolution of tin in tartar, or its acid, if metallic tin itſelf be not at the ſame time preſent.

That the ſolution of tin is made in the acid of tartar by a calcination of that metal; that the copper tends to attract and combine with the diſſolved metal, but cannot ſeparate it from the calcined matter; but that the calcining matter having a tendency to unite with the metallic tin already preſent in the maſs, is by this means ſolicited to quit the diſſolved tin, which it does in part. The conſequence is, that a ſmall portion of the tin combines with the copper in the metallic ſtate, and another portion of tin is taken up, accurately ſufficient to ſet the ſeveral tendencies in equilibrio.

This precipitation does not take place when the acid of tartar predominates greatly, and ſtill leſs if the ſolution be ſaturated with a calx of tin in a higher ſtate of calcination. For in the firſt caſe the unſaturated acid retains the tin by a power too ſtrong to be overcome by the attraction of the copper, and in the latter caſe the calcining matter acts on the tin nearly in the ſame way.

The precipitation of the tin takes place, if the acid of tartar has recently diſſolved a ſmall portion of iron in the metallic ſtate. For iron recently diſſolved is very ſtrongly diſpoſed to combine with the calcining matter; and by that means favours the reduction of the tin.

M. Gadolin further remarks, that tin is more abundantly diſſolved in tartar, or its acid, if tin in a ſtate of higher calcination be previouſly diſſolved; and that the action of the acid is ſtill more effectual, if the calx of copper be previouſly diſſolved in it. And in this caſe the metallic copper preſented is covered with a dirty pellicle. In theſe experiments (13, 14, 15) the metals previouſly diſſolved are precipitated in the metallic ſtate. And hence it is ſeen that thoſe who are engaged in this buſineſs ought to be careful to avoid any impurity or ſcoria of copper in their mixtures.

From the ingenious ſolution this chemiſt affords to the difficulty attending the precipitation of tin by copper in this proceſs, by the attraction exiſting between the two metals and the different degrees of calcination, it is evident how important it is to pay a due attention to all the circumſtances of chemical operations, and particularly this laſt. The Baron de Gedda on this occaſion made ſeveral experiments, which led to a cloſer inveſtigation on the part of Profeſſor Gadolin.

The Baron whitened copper by boiling it with tartar and tin. He alſo tried alum and common ſalt, together and ſeparately. The alum anſwered particularly well. His remarks on the theory of the Profeſſor were, in ſhort, that the ſubject did not appear to be ſufficiently mature to admit of a clear explanation, particularly as the effect is attributed to a ſimple attraction, and ought to ſucceed with an addition of iron, after taking out the metallic tin, which he tried in various ways without ſucceſs.

In his ſecond ſet of experiments, M. Gadolin ſhews more ſtrongly that the copper need not be acted on by the acid in the proceſs, by repeating the experiments with cream of tartar, tin, and a piece of fine gold. The gold was well tinned, though the acid of tartar had aſſuredly no action on it.

With regard to the precipitation of the tin upon the copper by the addition of iron, after the leaves of tin were taken out, he did not indeed find it take place in trials with the acid of tartar, which he attributed to the ſlight action of this acid. And accordingly he found that it ſucceeded when tin and alum were boiled together; the tin then taken out, and a plate of copper boiled in the ſolution, with a few filings of iron. The iron was ſtrongly acted on, and the copper in a few minutes covered with a pellicle of tin.

The following experiments tend alſo to throw further light on the ſubject. One part of tin in leaves was added to two parts of vitriol of copper diſſolved in water. The mixture was kept in a cloſe phial for ſeveral days, in a moderate heat and occaſionally agitated: After ſome days the green colour had diſappeared, the copper had fallen down, and the ſolution by the teſt of volatile alkali gave an abundant precipitate of calx of tin, but no trace of copper. Of this vitriolic ſolution of tin one part was added to a plate of copper and leaves of tin; a ſecond part was added to a plate of copper and another of iron; and the third was added to a plate of copper alone. Theſe three mixtures, in ſeparate phials, quite full and well cloſed, were kept in a moderate heat for ſome hours; after which the copper in the firſt was found to be covered with an even poliſhed pellicle of tin, but a

little

little dull and blueiſh. In the ſecond the copper was alſo tinned, but leſs uniformly; and the iron was every where well covered. In the third the copper was not at all changed.

The ſolutions in the firſt ſet of experiments, which contained copper, and were unfit for this operation, were rendered fit for the purpoſe by firſt precipitating the copper by ebullition with tin. The ſame effect took place with the aluminous ſolution of tin contaminated with copper.

Unequal proportions of tartar, alum, and common ſalt, are uſed in the arts for whitening copper. When a bright and ſhining ſurface is required rather than an high degree of whiteneſs, the ſolution of tartar is to be preferred. The ſolution of alum gives merely an exquiſite whiteneſs, and is to be preferred where a clear dead white, as it is called, is wanted. Tartar and common ſalt are added to diminiſh the appearance of want of poliſh the ſolution of alum gives to the blanched metal. Gadolin found that a mixture of one part of white tartar or cream of tartar, two of alum, and two of common ſalt, is the moſt uſeful ſolvent for this purpoſe, and very well calculated to ſucceed.

TOBACCO (Petum, Nicotiana, herba medicea, &c.) was firſt diſcovered in the iſland Tobago; brought into Europe in the year 1559 or 1560, by Mr. Nicot the French ambaſſador in Portugal, and preſented to queen Catherine de Medicis. It is now become the object of very extenſive manufactures, and cultivated in large quantity by the European colonies in America, as alſo in ſome parts of Europe. There are different ſpecies of the plant, and great differences alſo in the qualities of one ſpecies according to the ſoil and climate: ſtill further differences are occaſioned in the prepared tobaccos and ſnuffs from the manner of preparation, and the additions made uſe of for communicating colour, flavour, &c.

The leaves of this plant, taken internally, prove virulently emetic, cathartic, and narcotic: even in the common forms in which they are employed in ſuch immenſe quantities, they generally at firſt diſorder the conſtitution, till habitual uſe, which ſubdues many noxious things, has rendered them perhaps innocent, and perhaps even neceſſary. Diſtilled in a retort without addition, they yield an acrid empyreumatic oil, which has been found from repeated trials to be poiſonous to ſundry animals: it is probably on this oil that the effects of the ſmoke of tobacco depend, for when the plant is ſet on fire, its native qualities are deſtroyed.

Tobacco loſes its virulence by long coction in water, though all the active parts of the herb are extracted by the water; yet the extract left upon evaporating the liquor, taken in doſes of four or five grains, proves mildly aperient and anodyne, and is ſaid to be of great ſervice in diſorders of the breaſt: the longer the coction is continued, a ſuitable quantity of water being added for that purpoſe, the milder is the extract.

Neumann analyſed three ſorts of tobacco, the American caniſter tobacco, the Dutch leaf, and the dried leaves of our own growth. An ounce of the caniſter, treated firſt with water, gave four drams thirty grains of extract; the ſame quantity of the Dutch, four drams; of our own, four drams fifty grains. From the reſiduum of the firſt, rectified ſpirit extracted thirty grains; from that of the ſecond, ſixty; and from that of the third, thirty. An ounce of the caniſter ſort, treated firſt with rectified ſpirit, yielded one dram thirty grains; the ſame quantity of the Dutch, two drams twenty grains; and an ounce of ours, two drams thirty grains. From the reſiduum of the firſt, water extracted three drams thirty grains; from that of the ſecond, two drams forty grains; of the third, two drams thirty grains: the indiſſoluble earthy matter amounted in each of the experiments to three drams.

The ſpirituous extracts made from all the ſorts were ſtronger than the watry; that of the caniſter ſort was notably pungent on the tongue; of the Dutch, only bitteriſh, without any acrimony; the ſpirituous extract of ours taſted ſomewhat pungent, but the watry only bitter. The ſpirituous extracts of all the ſorts are of a fine green colour, the watry of a yellowiſh brown. The diſtilled waters and ſpirits have no taſte or ſmell. Bohn, however, pretends that the diſtilled water, eſpecially if drawn from the juice of the herb, will occaſion vomiting if taken to the quantity of an ounce or two.

TOPAZ. See Precious Stones, No. 4.

TOPHI. Duckſtein of the Germans, Pori. Kirwan ſays that theſe differ from the calcareous ſtalactites, not only in ſhape, but principally in this, that they have been formed by a gradual depoſition of earths, chiefly of the calcareous kind, barely diffuſed through water itſelf, and not in air. Hence they are of a ſoft and porous texture, and of the ſame colour as the ſtalactites.

The word tophi is alſo uſed as ſynonymous with tufa or traaſs, which is a volcanic product. Great heaps of tufa, or tophi, are found in Italy, forming various hills, and covering large tracts of land, from whence it is cut and carried for making the walls, vaults, and upper ceilings of houſes; it is a very ſoft kind of ſtone, extremely advantageous for theſe purpoſes, on account of its ſmall weight, and being eaſily cut into any form. The inhabitants of Umbria and other parts of Italy, dig with very little labour various ſubterraneous corridores and large excavations under earth, where they keep wines and many proviſions quite free from the irregularities and exceſſes of temperature.

TORREFACTION. This name is given to a kind of calcination by which ores are deprived of the volatile mineraliſing ſubſtances, the ſulphur and arſenic which they contain. It is alſo applied to ſignify the roaſting of ſome pharmaceutical preparations. Thus, for inſtance, we ſay torrefied rhubarb, &c.

TORSTEN. An iron ore of a bright blueiſh black, or yellowiſh gray colour, and fibrous texture, ſhews a red trace when ſcratched, and is weakly magnetic before calcination. According to Rinman, it is leſs dephlogiſticated than hæmatites.

TOUCHSTONE. The black baſaltes is uſed for examining the precious metals by the touch, and is commonly diſtinguiſhed by this name. See Assay.

TOURMALIN. See Precious Stones, No. 11.

TRAASS. See Tarras.

TRAGACANTH GUM. See Gums.

TRANSMUTATION. See Metals.

TRAPP. A dark gray or black ſtone, generally inveſted with a ferruginous cruſt, and cryſtallized in opake triangular or polyangular columns, is called baſaltes; that which is irregular, or breaks in large thick ſquare pieces, is called trapp, from its reſemblance to ſtairs, of which trap is the Swediſh name. Their conſtituent principles and relation to acids and fluxes are exactly the ſame. The texture of this ſtone is either coarſe, rough, and diſtinct, or fine and indiſcernible. This latter ſort is often reddiſh; it is always opake, and moulders by expoſure to the air; ſome ſpecimens give fire with ſteel very difficultly, though it is always very compact; ſometimes it is ſprinkled over with a few minute ſhining particles: its ſpecific gravity is 3,000.

When heated red hot, and quenched in water, it becomes by degrees of a reddiſh brown colour: it melts per ſe in a ſtrong heat into a compact ſlag. Borax alſo diſſolves it in fuſion, but mineral alkali not entirely.

TRIP. See Tripoli.

TRIPOLI EARTH. See Rotten Stone.

TRITORIUM. A veſſel generally made of glaſs, uſed for the ſeparation of liquors of different denſities, as oil and water. Its largeſt diameter is the middle, and it terminates with an aperture at each of the two extremities. The lower extremity, the aperture of which is very narrow, is dipped into the mixed liquor; and when it is ſufficiently filled, the upper orifice is to be ſtopped cloſe, by preſſing the thumb upon it, by which means the liquor contained will not run out at the lower aperture when the veſſel is raiſed from the mixed liquor. When the fluids, of which this liquor conſiſts, have perfectly ſeparated according to their reſpective denſities, by removing the thumb the heavier fluid will run out at the lower extremity, and the ſeparation will be thus effected.

TRITURATION is an operation which conſiſts in the mechanical diviſion of bodies, and is executed by the ſame methods, and by the ſame inſtruments that are employed for other diviſions of this kind; that is to ſay, in mortars, upon porphyries, and in mills. This word is generally applied to denote the grinding of ſeveral bodies together, to unite them with each other; as for inſtance, the extinction of mercury in the operation of ethiops mineral, and others of a ſimilar kind.

TROMPE. The trompe, or blowing machine, is formed of a hollow tree which reſts upon a caſk whoſe lower head is knocked out, and the open part of the caſk itſelf plunged to a certain depth under water. A current of water is made to fall through this wooden trunk upon a ſtone which is erected in the middle of the caſk. The air becomes diſengaged, and is obliged to paſs out at a collateral aperture in the caſk, by means of a tube which carries it to the lower part of the furnace. This air is afforded, 1. by that air which the water carries along with it: 2. by a current which paſſes through apertures made at the diſtance of ſix feet from the ſummit of the tree, and called trompilles. I uſe the French names, becauſe I do not know of any appropriated Engliſh terms.

The dimenſions of a good trompe, according to Chaptal, are the following:

Length of the tree or wooden trunk, from its ſummit to the ſide apertures or trompilles, ſix feet.

Length of the tree from the trompilles to the caſk, eight feet.

Height of the caſk, five feet.

Diameter of the caſk, four feet ſix inches.

The form of the internal part of the trunk, above the trompilles, is that of a funnel, whoſe ſuperior opening is eighteen inches, and its inferior diameter five.

The diameter of the cavity of the tree, below the trompilles, is eighteen inches.

The diameter of the trompilles is ſix inches.

Dr. Lewis, in his Philoſophical Commerce of Arts, treats expreſsly on this ſimple and uſeful inſtrument, on which he made many experiments. The following remarks, references, and inveſtigations, are abridged from his work.

The earlieſt method of animating the large fires of the furnaces for ſmelting ores, appears to have been by expoſing them to the wind. Such was the practice of the Peruvians before the arrival of the Spaniards in that country. Alonſo Barba relates, that their furnaces, called guairas, were built on eminences, where the air was freeſt;

that they were perforated on all ſides with holes, through which the air was driven in when the wind blew, which was the only time the work could be carried on; that under each hole was made a projection of the ſtone work on the outſide, and that on theſe projections were laid burning coals to heat the air before its entrance into the furnace. Some authors ſpeak of ſeveral thouſands of theſe guairas burning at once on the ſides and tops of the hills of Potoſi.

It is ſaid that ſeveral remains of a like rude proceſs are to be ſeen in ſome parts of our own country. The old blomery hearths, as they are called, for the running down of iron ore, are all on the tops of hills; a ſituation which can ſcarcely be ſuppoſed to have been choſen on any other account than for the conveniency of the wind, being in other reſpects extremely incommodious.

The gradual ſucceſſion of bellows to this inſufficient mode of ſupplying air, cannot perhaps be traced. It appears, that at ſome of our iron furnaces, and others, the bellows were formerly moved by a handle, as thoſe of the ſmith's forge, or by the preſſure of the foot upon a treadle, or by other means requiring the ſtrength of men; and that ſince the force of water has been called in aid to move them, the quantity of ore run down has not only been far greater, but the ſeparation of the metal more complete.

The firſt account that is to be met with of a machine for propelling air into furnaces, by a fall of water carrying down air with it, is of one at the copper or braſs furnaces at Tivoli, near Rome*. In this machine a ſquare wooden pipe of conſiderable width, and open at both ends, is placed upright. A ſtream of water runs in at the top, and is diſcharged at the bottom; and about the middle of the height of the pipe a ſmaller horizontal one is inſerted, which reaches to the furnace, and is ſaid to convey to it a ſtrong blaſt of air.

According to M. Belidor†, a pipe with air holes, inſerted into an air veſſel, is uſed for this purpoſe in ſome parts of France.

M. Mariotte ‡ gives an account of a contrivance for blowing fire by a fall of water, which conſiſts of a funnel and pipe, without air holes, inſerted into an air veſſel.

Mr. Stirling ‖ deſcribes a machine erected in Scotland, for blowing air into the furnaces in which lead ores are ſmelted, and for conveying freſh air into the works. This machine conſiſts of a funnel and pipe, with air holes, inſerted into an air veſſel.

The blowing machines uſed in Dauphiny for the forges and ſmelting furnaces, have a great reſemblance in their general ſtructure to the foregoing.

In the county of Foix, the blowing machines, as deſcribed by Reaumur §, are conſiderably different from the foregoing. The pipe is rectangular, and the part above the choak divides into three funnel-ſhaped partitions. On the top is a reſervoir or ciſtern of water; and two of the partitions, cloſe on all ſides, paſs up above the ſurface of the water, for carrying down air, and thus ſupplying the place of the lateral air holes: the water enters into the third partition, which is only the ſpace between the two foregoing, and which has but two ſides, formed by the two oppoſite ſides of the others.

Mr. Barthes ¶ gives a minute deſcription of a blowing machine at the forge of St. Pierre, on the river Obriou. Its general ſtructure is nearly the ſame with that of Foix, but the height of water above the choak much leſs.

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* See the third number of the Philoſophical Tranſactions, and the Journal des Savans for 1666.

† In his Architecture Hydraulique. ‡ In his Treatiſe du Mouvement des Eaux. ‖ In No. 576 of the Philoſophical Tranſactions for the year 1745. § In the Art des Forges. ¶ Vol. iii. of the Memoirs of the Correſpondents of the French Academy.

Dr. Lewis's trials, though not carried to ſuch a length as he could have wiſhed, ſatisfied him and thoſe who aſſiſted at them, that much more air is to be obtained by dividing the ſtream by means of a cullender, than by any other methods that have been tried; and that with ſuch a machine as that of St. Pierre above deſcribed, a ſtream of a hundred and fifty gallons at moſt in a minute is ſufficient to produce a continued blaſt from a pipe of three quarters of an inch bore, of ſuch ſtrength as to ſupport a column of water of three feet or more.

His ſummary view of the moſt material particulars which his experiments have diſcovered, with regard to the perfection of the ſtructure of blowing machines, and his deſcription from them of ſuch a machine as promiſes to be the moſt effectual, are as follow:

The bottom of the reſervoir of the water ſhould be about fourteen feet above the level of the ground: we need not be very ſolicitous about procuring a greater height; for though a greater would be of ſome advantage, yet this advantage appears to be much leſs conſiderable than has been commonly imagined. In the channel by which the water is conveyed, are to be placed gratings of different ſizes; and before the aperture a finer grating, which may be either a perforated iron plate or a wire ſieve, to ſerve as ſtrainers for keeping back ſuch matters as would obſtruct the apertures which the water is afterwards to paſs through. The ſtream ſhould enter at one ſide, or be ſo managed, that the water in the reſervoir or funnel may not be agitated by it, or put into a ſpiral motion, which Dr. Lewis's experiments ſhewed to be very injurious.

In the bottom of the reſervoir is to be made a round hole, for admitting the upper end of a cylindrical pipe of copper or caſt iron, five or ſix inches in the bore, and ſeven feet long. To the end of this pipe is to be fitted a cullender about a foot long, with the holes triangular, of half an inch each ſide, and ſix or ſeven ſpaces from top to bottom, at equal diſtances, muſt be left without holes, for admitting air to paſs down to the lower ſtreams. All the holes ſhould be directed downwards, that the ſtreams may not be forcibly projected againſt the ſides of the pipe which is to receive them, ſo as to have their velocity too much diminiſhed.

If there are ſix of the perforated ſpaces in the cullender, the number of holes in each may be twenty; ſo that the whole number will be one hundred and twenty. The ſide of each of the triangular holes being half an inch, the area of each will be the eighth part of a ſquare inch, and the ſum of their areas will be fifteen ſquare inches. The quantity of water running through one aperture of ſuch an area, at the depth of ſeven feet and a half under the ſurface, comes out on calculation about ſix hundred and twenty-two gallons in a minute; but the real quantity will doubtleſs be much leſs than this, on account of the great friction of the water in paſſing through a number of ſmall holes, and of the reſiſtance of the air, which increaſes in a very high ratio according to the increaſe of the velocity and enlargement of the ſurface: it is in part to make up for theſe retardations, that the pipe is directed to be made ſo high. The ſurface of the water is here above thirteen times greater than if it paſſed all through one circular aperture.

Both the pipe and the cullender ſhould have a flanch or rim round their orifices, and be ſecured to one another by ſcrews paſſing through the rims of both, with a plate of lead between them to make the juncture tight, as commonly practiſed in joining iron pipes for water works. This way of joining them admits the cullender to be taken off and cleaned, when a diminution of the effect of the machine ſhews the holes to be choaked up; which, however, it is apprehended, will ſeldom if ever happen.

As the holes will permit more water to run through than may at all times be wanted, it is proper to have ſome contrivance for occaſionally cloſing a part of them. This may be effected by means of a thin copper pipe, open at both ends, as high as the cullender, and of ſuch width as juſt to drop into it. It will be eaſily conceived, that when this regiſter is let entirely down, the lateral holes will be covered, and the water admitted only to thoſe in the bottom; and that by raiſing it further and further, more and more of the lateral holes will be uncovered. The regiſter is to be hung by a wire to a croſs-bar over the reſervoir, by which it may be raiſed or lowered; and a ſcale or divided board may be adjuſted againſt the upper part of the wire, for ſhewing the height of the regiſter, or the number of holes cloſed by it.

The moſt commodious and effectual way of admitting air to the water appears to be that of hanging the throat of the funnel, in this caſe the cullender, within the wider receiving pipe; for by this means the air is admitted freely and uniformly all round. This laſt pipe ſhould likewiſe be of iron or copper, twelve inches in diameter, and ſpread out at top to the width of ſixteen or eighteen inches, that a large ſpace may be left round the cullender: this ſpace ſhould reach three or four inches above the uppermoſt perforations of the cullender, to prevent any of the water from being daſhed over the top.

A pit is to be ſunk in the ground, not leſs than ſix feet deep. In this is to be placed an air veſſel, made of wood lined with lead, without a bottom, three or four feet in width, and ten or eleven high. The veſſel ſhould be ſupported on feet of a proper ſtrength, with ſufficient ſpaces between them for the water to paſs freely out: this way is preferable to the common one of placing the lower edge of the veſſel on the bottom of the pit, and cutting an aperture in the ſide, becauſe the height of the aperture is ſo much taken off from that of the veſſel. The reſervoir being fourteen feet above the ground, and the upper pipe and cullender reaching down eight feet, only ſix feet remain below the cullender; ſo that the air veſſel having ſix feet ſunk, the ground will reach nearly up to the cullender, and almoſt the whole height of the undermoſt pipe will be included within the veſſel. This pipe may be above nine feet long, three feet or more of it going down into the pit; which three feet are here an entire gain in the height of the fall, for the pipe in the other machines comes at moſt no lower than the level of the ground where the water runs off on the outſide. This height is gained in virtue of the compreſſed air in the veſſel puſhing down the water below: it may be always as great as the height to which the water is intended to riſe in the gage. At the diſtance of five or ſix inches under the orifice of the pipe is to be placed the concave iron plate or ſtone for the water to fall on. In the top of the air veſſel is to be fixed the gage and the blowing pipe.

Such is the general conſtruction of the blowing machine, which (ſays Dr. Lewis) promiſes to be particularly uſeful in caſes where water is ſcarce, or where the want of a natural fall renders it neceſſary to raiſe, by very expenſive means, the great quantities requiſite for working the common bellows. Dr. Lewis thinks too, that one of theſe machines will be ſufficient for the iron forge, and for ſundry other purpoſes where the quantity of air is not required to be very great; that it will be leſs expenſive, on account of the durability of its materials and the ſimplicity of its ſtructure, than any kind of bellows now in uſe; and what is of principal importance, that much leſs water will ſerve for working it. He adds, in caſes where one of the machines cannot ſupply air enough, as for the large iron ſmelting furnace, two pipes may be uſed, both fed by one reſervoir, and entering into one air veſſel. The uſing of two pipes appears more eligible than enlarging the bore of one; for air cannot be ſo freely introduced into a large body of water, though divided into ſtreams by the cullender, as into two ſmaller ones of equal quantity.

It may be obſerved, that the blaſt will be ſtronger in a denſe ſtate of the atmoſphere than when it is more rare or expanded, a greater quantity of air being then introduced under an equal volume. If therefore the quantity of water has been adjuſted ſo as to raiſe the gage to a proper height when the air was light, it will frequently happen that the ſame quantity of water ſhall raiſe it higher, and conſequently, if no greater height is required, that a part of the water may be ſaved. As the gage of the machine diſcovers by inſpection the variations in its effect, the regiſter affords convenient means of regulating its power, and increaſing or diminiſhing the quantity of water.

The method of blowing in our large furnaces is by iron bellows or machines, worked by a ſteam engine. Some years ago I had a converſation on this ſubject with one of our moſt eminent iron maſters, whoſe name I ſhould be glad to mention as a credit to myſelf, if I had at this time an opportunity of aſking his permiſſion.

The air machines are iron cylinders ſix feet in diameter, in which a piſton works with a ſtroke of ſeven feet in length. Each ſtroke therefore protrudes 198 cubic feet of air. At beſt the rate of working is ſixteen ſtrokes in a minute. The denſity of the air is ſuch that it will raiſe three pounds weight on a ſquare inch hole in the piſton, in which effect the ſtroke has ſome part. For the preſſure in the reſervoir is leſs, being about two pounds on the ſame ſurface. The reſervoir, called the regulating belly, is a large cloſe chamber open below, and ſurrounded with a ſufficient maſs of water to riſe within it, and by its reaction keep up the denſity of the air with which its upper part is ſupplied from the cylinder. The difference of height between the ſurfaces of the water within and without the reſervoir is between ſix and ſeven feet, and the riſe and fall at each ſtroke of the piſton is about four or five inches on the outer ſurface. I think he afterwards ſaid two or three. From this laſt datum we may deduce the ſize of the regulating belly or its horizontal ſection. For its ſurface will be to that of the piſton, inverſely as this riſe is to the length of the ſtroke. If the medium of the firſt numbers be taken, its ſurface will be 19 times that of the piſton, which is 28$\frac{1}{4}$ ſquare feet, that is to ſay, 536 ſquare feet, or a ſquare whoſe ſide is 23 feet. But if the medium of the ſecond numbers be taken, the ſurface will be 45 times that of the piſton, that is 1271 ſquare feet, or a ſquare whoſe ſide is about 36$\frac{1}{2}$ feet. The larger this ſurface, the ſteadier the blaſt. From the regulating belly proceeds the nozle or twyer (tuyere) as it is called. Its diameter at the aperture is one, two, or three inches. They have ſometimes enlarged them for experiment as far as five; but they then found the apparatus not to ſupply the air quickly enough, or at leaſt not with the ſame advantage as when a ſmaller aperture was uſed.

If we attend to the height of the water on the outſide of the reſervoir, we ſhall find the force of this apparatus to be greatly beyond that of the other bellows in uſe. Six or ſeven feet of water upon the baſe of a ſquare inch will give 72 or 84 ſolid inches, and thoſe at 1000 ounces to the cubic foot, or 1728 inches will give 41 ounces, or two pounds nine ounces for the preſſure upon a ſquare inch, repreſented by the firſt of theſe numbers. The ſecond number will give near 48 ounces, or three pounds. Theſe preſſures referred to a column of mercury, which is a very uſual and convenient method of admeaſurement, will correſpond to 5.3 and 6.2 inches elevation of that fluid; that is to ſay, at moſt not one fifth of an atmoſphere.

In ſome of the early volumes of the Abridgment of the Tranſactions, there is an account of a method of conveying air to vaſt diſtances, through pipes for the purpoſe of blowing, and as I think, ſpeaking from recollection, for the communication of mechanic effect. This ſcheme was put in practice by the father of the iron maſter from whom the preceding information was received. The project, which did not ſucceed, coſt four thouſand pounds. Three engines were erected, conſiſting of bellows worked by large water wheels, at a fall of water eighteen hundred yards diſtant from the iron work to which the air was intended to be conveyed. A pipe ten inches diameter conveyed the air from the engine to the works, and the ſtream of air was never ſo ſtrong as to blow out a candle. So I find it in my notes; but I think, from recollection, the expreſſion was, to affect the flame of a candle, and certainly a very gentle breath of air was meant. The engine worked but a few ſtrokes before it ſtopped. The proprietor concluded that the pipe was in ſome part deſignedly obſtructed; but upon advice, he put a cat into the pipe, which walked through it and came out at the other end. It remained, therefore, to aſcertain whether the obſtruction of the air aroſe merely from the length of the pipe. For this purpoſe holes were cut in the pipe at various diſtances from the end at which the air entered, and proper coverings prepared, that each might be opened at pleaſure. It was found that the engine worked ſlower, the remoter the hole which was opened, the wind iſſuing of courſe with leſs ſtrength; and when the hole was made at a certain diſtance, it ſtopped. I did not aſk the diſtance. It is ſaid that the paſſage of air from a blowing machine to its place of eſcape is conſiderably impeded through pipes of the length of 40 or 50 feet. The fact, which is perfectly authentic, is certainly very curious. Whether it is to be aſcribed to the loſs by friction of a momentum, in which the velocity is ſo great and the maſs ſo ſmall; or whether there be any effect ſimilar to that ſtickage which takes place when wool, or other elaſtic bodies are rammed into a tube, muſt be determined from a numerical eſtimate of all the facts, and may perhaps require new experiments. I cannot help, however, entertaining the opinion, that the former cauſe is the moſt effectual in this buſineſs, and that the undertaking here deſcribed might have been made to anſwer by enlarging the diameter of the tube. For if the impediment be friction ariſing from the velocity of the maſs, that element will diminiſh in proportion as the diameter of the tube is increaſed, and the quantity of ſurface rubbed againſt by the ſame maſs of air will not alter. Hence, it ſhould follow, that if a tube, of an inch diameter and three feet long, do not perceptibly reſiſt the paſſage of the air, another tube thirty feet long, will afford no more reſiſtance, provided its diamete be ten inches, that is to ſay, proportional to its length.

TUFA. See Tophi.

TUNGSTEN is a mineral of an opake white colour, very heavy, and o a moderate degree of hardneſs: its cryſtals are octahedrons. Its ſpecific gra is 6.0665, according to Briſſon; from 4.99 to 5.8, according to Kirwan.

This ſubſtance has a ſparry appearance, and was long confounded wit white tin ore. It is found at Bitſberg, at Riddharhittan, at Marienberg, at Altemberg in Saxony, and at Sauberg near Ehrenfriederſdorff.

Mr. Raſpe, in Crell's Annals for June 1785, gave an account of two mines of tungſten in the province of Cornwall, from which thouſands of tons might be extracted. This philoſopher obtained the metal in the proportion of about thirty-ſix livres the quintal. He adds that this metal contains little iron; that it is very fixed and refractory in the fire; and that it acts on glaſs like the hardeſt ſteel.

The tungſten was formerly claſſed among iron ores; but it has been examined by Scheele, Bergman, and De Luyart. See Acid of Tungsten.

TURBITH MINERAL. This name is given to a preparation of mercury made in the following manner:

Some mercury is put into a glaſs retort, and upon it is poured an equal weight of concentrated vitriolic acid, or more, according to the degree of concentration of this acid. Theſe matters are to be diſtilled together in a ſand-bath till nothing remains in the retort but a dry ſaline ſubſtance, which is a combination of mercury with vitriolic acid. The union of theſe two matters cannot be directly effected but by this proceſs, becauſe the vitriolic acid cannot attack mercury unleſs it be highly concentrated, and becauſe this concentration cannot be performed ſo well in open as in cloſe veſſels. Beſides, the heat in this operation favours conſiderably the action of the acid upon the mercury. The acid which paſſes into the receiver during the diſtillation is very ſulphureous, from the loſs of vital air, which may be expelled again by heat from the mercurial calx.

The white ſaline maſs left at the bottom of the retort is to be put into a large veſſel, and upon it large quantities of hot water are to be poured at ſeveral different times. This water ſeparates the redundant acid, takes it from the mercury, which is then precipitated to the bottom of the veſſel, in form of a very ſhining yellow citron-coloured powder. This yellow mercurial powder, having been well waſhed, is called turbith mineral, and is a very powerful emetic.

The water with which it is waſhed contains a portion of acid that was united with the mercury; and alſo contains a little mercury in the ſaline ſtate, which is ſoluble in water, by means of the very large quantity of acid.

Turbith mineral may alſo be made by precipitating mercury from its ſolution in nitrous acid, by means of vitriolic acid, or of ſome vitriolic ſalt. For this purpoſe the nitrous acid muſt be well ſaturated with mercury; for if it contain any unſaturated acid, no turbith mineral will appear upon adding either vitriolic ſalts or pure vitriolic acid. Hence miſtakes may be committed in making experiments to diſover the preſence of vitriolic acid, by means of a ſolution of mercury, as is frequently done.

Turbith mineral becomes yellow only by being deprived of the adhering vitriolic acid, and remains white till it has been waſhed with a large quantity of water; in general, the more perfectly it is deprived of acid, the deeper yellow colour it acquires.

Turbith mineral has been formerly celebrated for the cure of the venereal diſeaſe; but it is now little uſed, becauſe preferable mercurial remedies have been diſcovered. See Acid (Vitriolic), and Mercury.

TURNSOLE. See Heliotropium.

TURKEY STONE. Cos Turcica. This ſtone is of a dull white colour, and often of an uneven texture, ſome parts appearing more compact than others, ſo that it is in ſome meaſure ſhattery. It is uſed as a whetſtone: and thoſe of the fineſt grain are the beſt hones for the moſt delicate cutting tools, and even for razors, lancets, &c. Its ſpecific gravity is 2,598. It gives fire with ſteel, yet efferveſces with acids. Kirwan found that 100 parts of it contain 25 of mild calcareous earth, and no iron.

There probably are two ſorts of ſtones known by this name, as Wallerius affirms that which he deſcribes neither to give fire with ſteel, nor efferveſce with acids. Workmen affirm that this ſtone hardens with oil. The value of ſuch ſpecimens as contain a very fine grit, or ſiliceous part, is much greater than that of the common ſamples. Artiſts ſelect them by trial; but it is not generally known that moſt of theſe ſtones have a fine and a coarſe ſide, and ought therefore to be ſawed with an attention to this circumſtance. It naturally ariſes from the ſtone having been formed from ſubſidence in water.

TURMERIC (terra merita) curcuma longa, is a root brought to us from the Eaſt Indies. Berthollet had an opportunity of examining ſome turmeric which came from Tobago, which was ſuperior to that which is met with in commerce, both in the ſize of the roots and the abundance of the colouring particles. This ſubſtance is very rich in colour, and there is no other which gives a yellow colour of ſuch brightneſs; but it poſſeſſes no durability, nor can mordants give it a ſufficient degree. Common ſalt and ſal ammoniac are thoſe which fix the colour beſt, but they render it deeper, and make it incline to brown; ſome recommend a ſmall quantity of muriatic acid. The root muſt be reduced to powder to be fit for uſe. It is ſometimes employed to give the yellows made with weld a gold caſt, and to give an orange tinge to ſcarlet; but the ſhade the turmeric imparts ſoon diſappears in the air.

Mr. Guhliche gives two proceſſes for fixing the colour of turmeric on ſilk. The firſt conſiſts in aluming in the cold for twelve hours a pound of ſilk in a ſolution of two ounces of alum, and dyeing it hot, but without boiling, in a bath compoſed of two ounces of turmeric and a quart (meſure) of aceto-citric acid (ſee page 234), mixed with three quarts of water. The ſecond proceſs conſiſts in extracting the colouring particles from the turmeric by aceto-citric acid, in the way deſcribed for brazil wood, and in dyeing the ſilk alumed as already mentioned in this liquor, either cold or only moderately warm. The colour is rendered more durable by this than by the former proceſs. The firſt parcel immerſed acquires a gold yellow; the colour of the ſecond and third parcels is lighter, but of the ſame kind; that of the fourth is a ſtraw colour. Mr. Guhliche employs the ſame proceſs to extract fine and durable colours from fuſtic, broom, and French berries; he prepares the wool by a ſlight aluming, to which he adds a little muriatic acid. He ſeems to content himſelf in theſe caſes with vinegar or ſome other vegetable acid, inſtead of his aceto-citric acid, for the extraction of the colour; he directs that a very ſmall quantity of ſolution of tin ſhould be put into the dye-bath.

TURPENTINE is a reſinous juice extracted from ſeveral trees. Sixteen ounces of Venice turpentine being diſtilled with water, yielded four ounces and three drams of eſſential oil; and the ſame quantity, diſtilled without water, yielded with the heat of a water bath two ounces only. When turpentine is diſtilled or boiled with water till it becomes ſolid, it appears yellowiſh; when the proceſs is further continued, it acquires a reddiſh brown colour. In the firſt ſtate it is called boiled turpentine; and in the ſecond colophony, or common roſin. On diſtilling ſixteen ounces in a retort with an open fire increaſed by degrees, Neumann obtained, firſt, four ounces of a limpid colourleſs oil; then two ounces and a dram of a dark browniſh red empyreumatic oil, of the conſiſtence of a balſam, and commonly diſtinguiſhed by that name.

The eſſential oil commonly called ſpirit of turpentine, cannot without ſingular difficulty be diſſolved in ſpirit of wine, though turpentine itſelf is eaſily ſoluble in that ſpirit. One part of the oil may be diſſolved in ſeven parts of rectified ſpirit of wine; but on ſtanding a while, the greateſt part of the oil ſeparates and falls to the bottom.

TURPETH. See TURBITH.

TUTENAG. This name is given in India to the ſemi-metal zinc. It is ſometimes applied to denote a white metallic compound brought from China, called alſo Chineſe copper, the art of making which is not known in Europe. It is very tough, ſtrong, malleable, may be eaſily caſt, hammered, and poliſhed; and the better kinds of it, when well manufactured, are very white, and not more diſpoſed to tarniſh than ſilver is. Three ingredients of this compound may be diſcovered by analyſis; namely, copper, zinc, and iron.

The above is a note of Keir upon Macquer. Some of the Chineſe white copper is ſaid to be merely copper and arſenic.

Mr. Engeſtrom, in the Memoirs of Stockholm for the year 1775, quoted by Kirwan, has given us an analyſis of a tutenag ore from China. It was of a white colour, interſperſed with red ſtreaks of calx of iron, and ſo brittle as to be eaſily broken betwixt the fingers. In the dry way it exhibited the ſame appearances as zinc ſpar, except that it loſt no part of its weight. It was ſoluble in the mineral acids, particularly with the aſſiſtance of heat, and with the vitriolic afforded vitriol both of zinc and iron. The quantity of fixed air was ſo ſmall as to be abſorbed by ſolution. It contained in various ſpecimens from 60 to 90 per cent. of zinc; the remainder was iron, and a ſmall proportion of clay. This variety of calciform ores, which was mixed with a notable proportion of iron, was alſo diſcovered in Germany by Mr. Bindheim, who found it to conſiſt of zinc, a little iron, and ſilex. 4 Berl. Schrift. 400.

TUTTY. A metallic ſubſtance, various in its compoſition and properties, which nevertheleſs appear to depend on the preſence of zinc. The better ſorts of tutty, according to Neumann, are in ſemi-cylindrical concave pieces, like the bark of a tree; ponderous and ſomewhat ſonorous; moderately compact, and generally not eaſy to break; of an aſh or mouſe-gray colour, often with yellow or green variegations; pretty ſmooth on the inſide, full of cavities or protuberances on the outſide. The entire, compact, gray pieces are preferred; the broken, powdery, crumbly, yellow, or reddiſh, rejected. Boecler relates that tutty has a ſharp taſte, but no ſuch taſte is perceptible in ours.

Wiegleb affirms that the matter which in the fuſion of braſs is depoſited over the melted metal is called tutty; but Neumann made various unſucceſsful enquiries relative to its origin, and the place where it may be produced. That it is not produced at Goſlar, or Schneeberg, nor at any of the conſiderable founderies of braſs, bronze, bell-metal, &c. in Germany, Holland, France, Italy, and England, he affirms from his own experience. He therefore concludes that it is an artificial production, expreſsly made up of the calx of zinc, with clay and other matters.

TYPE METAL. The baſis of type metal for printers is lead, and the principal article uſed in communicating hardneſs is the regulus of antimony, to which copper and braſs in various proportions are added. The properties of a good type metal are, that it ſhould run freely into the mould, and poſſeſs hardneſs without being exceſſively brittle. The ſmaller letters are made of a harder compoſition than thoſe of a larger ſize. It does not appear that our type founders are in poſſeſſion of a good compoſition for this purpoſe. The principal defect of their compoſition appears to be, that the metals do not uniformly unite. In a piece of caſting performed at one of our principal founderies, the thickneſs of which was two inches, I found one ſide hard and brittle when ſcraped, and the other ſide, conſiſting of nearly half the piece, was ſoft like lead. The tranſition from ſoft to hard was ſudden, not gradual. If a parcel of letter of the ſame ſize and caſting be examined, ſome of them are brittle and hard, and reſiſt the knife, but others may be bended and cut into ſhavings. It may eaſily be imagined that the duration and neatneſs of theſe types muſt conſiderably vary. I have been informed, but do not know the fact from trial, that the types caſt in Scotland are harder and more uniform in their qualities.

V

VAPOUR. The elaſtic fluids or ſubtle inviſible matters which fly off from bodies ſubjected to chemical operations or otherwiſe, are called vapours. But accurate chemical writers confine this appellation to ſuch exhalations only as may be condenſed into the fluid ſtate by cold, in contradiſtinction to the aerial fluids, of which ſcarcely any are ſo convertible by any means in our power.

VARNISH. Lac varniſhes or lacquers conſiſt of different reſins in a ſtate of ſolution, of which the moſt common are maſtich, ſandarach, lac, benzoin, copal, amber, and aſphaltus. The menſtrua are either expreſſed or eſſential oils, as alſo ſpirit of wine. For a lac varniſh of the firſt kind, the common painter's varniſh is to be united by gently boiling it with ſome more maſtich or colophony, and then diluted again with a little more oil of turpentine. The latter addition promotes both the gloſſy appearance and drying of the varniſh. Of this ſort is the amber varniſh. To make this varniſh, half a pound of amber is kept over a gentle fire in a covered iron pot, in the lid of which there is a ſmall hole, till it is obſerved to become ſoft, and to be melted together into one maſs. As ſoon as this is perceived, the veſſel is taken from off the fire, and ſuffered to cool a little; when a pound of good painter's varniſh is added to it, and the whole ſuffered to boil up again over the fire, keeping it continually ſtirring. After this, it is again removed from the fire; and when it is become ſomewhat cool, a pound of oil of turpentine is to be gradually mixed with it. Should the varniſh, when it is cool, happen to be yet too thick, it may be attenuated with more oil of turpentine. This varniſh has always a dark-brown colour, becauſe the amber is previouſly half-burned in this operation; but if it be required of a bright colour, amber powder muſt be diſſolved in tranſparent painter's varniſh, in Papin's machine by a gentle fire. As an inſtance of the ſecond ſort of lac varniſhes with ethereal oils alone, may be adduced the varniſh made with oil of turpentine. For making this, maſtich alone is diſſolved in oil of turpentine by a very gentle digeſting heat in cloſe glaſs veſſels. A varniſh of the conſiſtence of thin turpentine is obtained for aeroſtatic machines, by the digeſtion of one part of elaſtic gum cut into ſmall pieces, in thirty-two parts of rectified oil of turpentine. Previouſly to its being uſed however it muſt be paſſed through a linen cloth, in order that the undiſſolved parts may be left behind. The third ſort of lac varniſhes conſiſts in the ſpirit of wine-varniſh. The moſt ſolid reſins yield the moſt durable varniſhes; but a varniſh muſt never be expected to be harder than the reſin naturally is of which it is made. Hence, it is the height of abſurdity to ſuppoſe that there are any incombuſtible varniſhes, ſince there is no ſuch thing as an incombuſtible reſin. But the moſt ſolid reſins by themſelves produce brittle varniſhes; therefore ſomething of a ſofter ſubſtance muſt always be mixed with them, whereby this brittleneſs is diminiſhed. For this purpoſe gum elemi, turpentine, or balſam of capaiva are employed in proper proportions. For the ſolution of theſe bodies the ſtrongeſt alcohol ought to be uſed, which may very properly indeed be diſtilled over alkali, but muſt not have ſtood upon alkali. The utmoſt ſimplicity in compoſition with reſpect to the number of the ingredients in a formula is the reſult of the greateſt ſkill in the art; hence, it is no wonder that the greateſt part of the formulas and recipes that we meet with are compoſed without any principle at all.

In conformity to theſe rules, a fine colourleſs varniſh may be obtained, by diſſolving eight ounces of gum ſandarach and two of Venice turpentine in thirty-two ounces of alcohol by a gentle heat. The following, which is obtained from five ounces of ſhell lac and one of turpentine, diſſolved in thirty-two ounces of alcohol by a very gentle heat, is harder, but of a reddiſh caſt. To theſe the ſolutions of copal and amber are undoubtedly preferable in many reſpects. The ſolution of the former is effected by triturating an ounce of powder of gum copal, which has been well dried by a gentle heat, with a dram of camphire, and, while theſe are mixing together, adding by degrees four ounces of the ſtrongeſt alcohol, without any digeſtion. But Wiegleb, from whom the foregoing is extracted, confeſſes, that he never could ſucceed in this way with amber.

Between this and the gold varniſh there is only this difference, that ſome ſubſtances that communicate a yellow tinge are to be added to the latter. The moſt ancient deſcription of two ſorts of it, one of which was prepared with oil, and the other with ſpirit of wine, is to be found in Alexius Pedemontanus De i Secreti, Lucca, of which the firſt edition was publiſhed in the year 1557. But it is better prepared, and more durable, when made after the following preſcription: Take two ounces of ſhell lac, of arnatto and turmeric of each one ounce, and thirty grains of fine dragon's-blood, and make an extract with twenty ounces of alcohol in a gentle heat.

Oil varniſhes are commonly mixed immediately with the colours, but lac or lacquer varniſhes are laid on by themſelves upon a burniſhed coloured ground: when they are intended to be laid upon naked wood, a ground ſhould be firſt given them of ſtrong ſize, either alone or with ſome earthy colour, mixed up with it by levigation. The gold lacquer is ſimply rubbed over braſs, tin, or ſilver, to give them a gold colour.

Pere d'Incarville has informed us, that the tree which affords the varniſh of China is called Tſi-chou by the Chineſe. This tree is propagated by off-ſets. When the cultivator is deſirous of planting it, he takes a branch, which he wraps up in a maſs of earth, by means of flax. Care is taken to moiſten this earth; the branch puſhes out roots, and is then pruned and tranſplanted. This tree grows to the ſize of a man's leg.

The varniſh is drawn in ſpring. If it be a cultivated tree, it affords three gatherings. It is extracted by inciſions made in the ſpring; and when the varniſh, which is received in ſhells, does not flow, ſeveral hogs briſtles moiſtened with water or ſaliva are introduced into the wound, and cauſe it to run. When the tree is exhauſted, the upper part of it is wrapped in ſtraw, which is ſet on fire, and cauſes the varniſh to precipitate to the bottom of the tree, where it flows out of perforations made for that purpoſe.

Thoſe who collect the varniſh ſet out before day-break, and place their ſhells beneath the apertures. The ſhells are not left longer than three hours in their place, becauſe the heat of the ſun would evaporate the varniſh.

The varniſh emits a ſmell which the workmen are very careful to avoid reſpiring. It produces an effect which they call the bud of the varniſh.

When the varniſh iſſues from the tree, it reſembles pitch. By expoſure to the air, it gradually becomes coloured, and is at laſt of a beautiful black.

The juice which flows from inciſions made in the trunk and branches of the thus toxicodendron, poſſeſſes the ſame properties. The tree that grows in the French climates affords a white milky fluid, which becomes black and thick by the contact of the air; its colour is the moſt beautiful black, and it would be eaſy to introduce this valuable ſpecies of induſtry into the kingdom, becauſe the tree grows wonderfully well in all climates, and reſiſts the cold of the winter.

To make the varniſh bright, it is evaporated by the ſun; and a body is given to it with hog's gall and martial vitriol.

The Chineſe uſe the oil of tea, which they render drying by boiling it with orpiment, realgar, and arſenic.

The fundamental facts in the art of varniſhing by reſins are reduced by Chaptal to the following principles.

To varniſh any ſubſtance, conſiſts in applying upon its ſurface a covering of ſuch a nature, as ſhall defend it from the influence of the air, and give it a ſhining appearance.

A coat of varniſh ought therefore to poſſeſs the following properties:—1. It muſt exclude the action of the air; becauſe wood and metals are varniſhed to defend them from decay and ruſt. 2. It muſt reſiſt water; for otherwiſe the effect of the varniſh could not be permanent. 3. It ought not to alter ſuch colours as are intended to be preſerved by this means.

It is neceſſary therefore that a varniſh ſhould be eaſily extended or ſpread over the ſurface, without leaving pores or cavities; that it ſhould not crack or ſcale; and that it ſhould reſiſt water. Now reſins are the only bodies that poſſeſs theſe properties.

Reſins conſequently muſt be uſed as the baſes of varniſh. The queſtion which of courſe preſents itſelf muſt be then, how to diſpoſe them for this uſe; and for this purpoſe they muſt be diſſolved, as minutely divided as poſſible, and combined in ſuch a manner, that the imperfections of thoſe which might be diſpoſed to ſcale, may be corrected by others.

Reſins may be diſſolved by three agents—1. By fixed oil. 2. By volatile oil. 3. By alcohol. And accordingly we have three kinds of varniſh : the fat or oily varniſh, eſſential varniſh, and ſpirit varniſh.

Before a reſin is diſſolved in a fixed oil, it is neceſſary to render the oil drying. For this purpoſe the oil is boiled with metallic calces, in which operation the mucilage of the oil combines with the metal, while the oil itſelf unites with the vital air of the calx. To accelerate the drying of this varniſh, it is neceſſary to add oil of turpentine.

The eſſential varniſhes conſiſt of a ſolution of reſin in oil of turpentine. The varniſh being applied, the eſſential oil flies off, and leaves the reſin. This is uſed only for paintings.

When reſins are diſſolved in alcohol, the varniſh dries very ſpeedily, and is ſubject to crack ; but this fault is corrected by adding a ſmall quantity of turpentine to the mixture, which renders it brighter, and leſs brittle when dry.

The coloured reſins or gums, ſuch as gum guttæ, dragon's blood, &c. are uſed to colour varniſhes.

To give luſtre to the varniſh after it is laid on, it is rubbed with pounded pumice ſtone and water; which being dried with a cloth, the work is afterwards rubbed with an oiled rag and tripoli. The ſurface is laſt of all cleaned with ſoft linen cloths, cleared of all greaſineſs with powder of ſtarch, and rubbed bright with the palm of the hand.

VEGETABLE KINGDOM. In the mineral kingdom little of chemical operation takes place, wherein the peculiar locality or diſpoſition of the principles which act upon each other appears to have any conſiderable effect. The principles for the moſt part ſimple act upon each other by virtue of their reſpective attractions; if heat be developed, it is for the moſt part ſpeedily conducted away ; if elaſtic products be extricated, they in general make their eſcape ;—in a word, we ſeldom perceive in the operations in the mineral kingdom any arrangement which at all reſembles the artificial diſpoſitions of the chemiſt. But in the animal and vegetable kingdoms it is far otherwiſe. In the former of theſe, bodies are regularly changed by mechanical diviſion, by digeſtion, and the application of peculiar ſolvents, in a temperature exceeding that of the atmoſphere, and the whole of the effects are aſſiſted, modified and kept up by an apparatu for admitting the air of the atmoſphere. The ſubjects of the vegetable kingdom poſſeſs undoubtedly a ſtructure leſs elaborate. They exhibit much leſs of thoſe energies which are ſaid to be ſpontaneous. The form of their veſſels is much ſimpler, and, as far as we can perceive, their action is obedient to the changes of the atmoſphere in quality and moiſture, the mechanical action of winds, the temperature of the weather, and the influence of light. In theſe organized beings, the chemiſt diſcovers principles of a more compounded nature than any which can be obtained from the mineral kingdom. Theſe do not previouſly exiſt in the earth, and muſt therefore be reſults of vegetable life.

The moſt obvious difference between vegetables and animals is, that the latter are in general capable of conveying themſelves from place to place ; whereas vegetables, being fixed in the ſame place, abſorb by means of their roots and leaves ſuch ſupport as is within their reach. This appears on the whole to conſiſt of air and water. The greateſt part of the ſupport of animals are the products already elaborated in the vegetable kingdom. The products of theſe two kingdoms in the hands of the chemiſt are remarkably different, though perhaps not excluſively ſo. One of the moſt diſtinctive characters ſeems to be the preſence of phlogiſticated air or azotic gas, which may be extricated from animal ſubſtances by the application of nitrous acid, and enters into the compoſition of the volatile alkali afforded by deſtructive diſtillation. It was long ſuppoſed, that volatile alkali was excluſively the product of the animal kingdom, but it is now well known that certain plants likewiſe afford it.

When it is conſidered, that by far the greater part of every organized ſubſtance is capable of aſſuming the elaſtic form, and being volatilized by heat; that the products are during life brought into combination by ſlow and long-continued proceſſes, and are kept ſeparate from each other in the veſſels of the plant or animal; that theſe combinations are liable to be altered by the deſtruction of thoſe veſſels, as well as by every notable change of temperature, it will not appear ſurpriſing that the chemical analyſis of plants ſhould be in a very imperfect ſtate. The ancient chemiſts had no other methods of examining plants than by deſtructive diſtillation, and the ſucceſſive application of water and ardent ſpirit. They had no method of examining the elaſtic products of their diſtillations. This method is on every account of little value. For the new combinations produced by the heat, exhibit products nearly ſimilar from ſubſtances originally very different. The other method by the application of ſolvents is ſomewhat more accurate, and has beſides afforded products of conſiderable utility in the arts and for the ordinary purpoſes of life. A ſlight ſketch of the requiſite manipulations has been given under our article Animal Kingdom.

In the ſtructure of vegetables we obſerve the external covering or bark, the ligneous or woody matter, the veſſels or tubes, and certain glandular or knotty parts. The comparative anatomy, and immediate uſes of theſe parts, form an object of intereſting reſearch, but leſs immediately within the province of a chemical work.

The nutrition or ſupport of plants appears to require water, earth, light, and air. There are various experiments which have been inſtituted to ſhew that water is the only aliment which the root draws from the earth. Van Helmont planted a willow, weighing fifty pounds, in a certain quantity of earth covered with ſheet lead: he watered it for five years with diſtilled water; and at the end of that time the tree weighed one hundred and ſixty-nine pounds three ounces, and the earth in which it had vegetated was found to have ſuffered a loſs of no more than three ounces. Boyle repeated the ſame experiment upon a plant, which at the end of two years weighed fourteen pounds more, without the earth in which it had vegetated having loſt any perceptible portion of its weight.

Meſſrs. Duhamel and Bonnet ſupported plants with moſs, and fed them with mere water: they obſerved that the vegetation was of the moſt vigorous kind; and the naturaliſt of Geneva obſerves, that the flowers were more odoriferous, and the fruit of a higher flavour. Care was taken to change the ſupports before they could ſuffer any alteration. Mr. Tillet has likewiſe raiſed plants, more eſpecially of the gramineous kind, in a ſimilar manner; with this difference only, that his ſupports were pounded glaſs, or quartz in powder. Hales has obſerved that a plant which weighed three pounds, gained three ounces after a heavy dew. Do we not every day obſerve hyacinths and other bulbous plants, as well as gramineous plants, raiſed in ſaucers or bottles containing mere water?

All plants do not demand the ſame quantity of water; and nature has varied the organs of the ſeveral individuals conformably to the neceſſity of their being ſupplied with this food. Plants which tranſpire little, ſuch as the moſſes and the lichens, have no need of a conſiderable quantity of this fluid; and accordingly they are fixed upon dry rocks, and have ſcarcely any roots: but plants which require a larger quantity, have roots which extend to a great diſtance, and abſorb humidity throughout their whole ſurface.

The leaves of plants have likewiſe the property of abſorbing water, and of extracting from the atmoſphere the ſame principle which the root draws from the earth. But plants which live in the water, and as it were ſwim in the element which ſerves them for food, have no need of roots; they receive the fluid at all their pores: and we accordingly find that the fucus, the ulva, &c. have no roots whatever. The purer the water, the more ſalutary it is to plants. Mr. Duhamel has drawn this conſequence from a ſeries of well-made experiments, by which he has proved that water impregnated with ſalts is fatal to vegetation. Hales cauſed them to abſorb various fluids by making inciſions in their roots, and plunging them into ſpirits of wine, mercury, and various ſaline ſolutions; but he was convinced that theſe were all poiſons to the vegetables. Beſides, if theſe ſalts were favourable to the plants, they would be again found in the individual which had been watered with a ſolution of them; whereas Meſſrs. Thouvenel and Cornette have proved that theſe ſalts do not paſs into the vegetable. We muſt nevertheleſs except the marine plants, becauſe the ſea-ſalt of which they have need is decompoſed in them; and produces a principle which appears neceſſary to their exiſtence, ſince they languiſh without it.

Though it is proved that pure water is more proper for vegetation than water charged with ſalts, it muſt not on that account be concluded, that water cannot be diſpoſed in a more favourable manner to the developement of vegetables, by charging it with the remains of vegetable and animal decompoſition. If, for example, the water be loaded with principles diſengaged by fermentation or putrefaction, the plant then receives juices already aſſimilated to its nature, and theſe prepared aliments muſt haſten its growth. Independent of thoſe juices already formed, the nitrogene gas, which conſtitutes one of the nutritive principles of plants, and is abundantly afforded by the alteration of vegetables and animals, muſt facilitate their developement. A plant ſupported by the remains of vegetables and animals, is in the ſame ſituation as an animal fed on milk only; its organs have leſs difficulty in elaborating this drink than that which has not yet been animalized.

The dung, which is mixed with earths, and decompoſed, not only affords the alimentary principles we have ſpoken of, but likewiſe favours the growth of the plant by that conſtant and ſteady heat which its ulterior decompoſition produces. Thus it is that Fabroni affirms his having obſerved the developement of leaves and flowers in that part of a tree only which was in the vicinity of a heap of dung.

From the preceding circumſtances it appears, that the influence of the earth in vegetation is almoſt totally confined to the conveyance of water, and probably the elaſtic products from putrefying ſubſtances to the plant. See ARABLE LANDS, and EARTH VEGETABLE.

Vegetables cannot live without air. From the experiments of Prieſtley, Ingenhouſz, and Senebier, it is aſcertained that plants abſorb the azotic part of the atmoſphere; and this principle appears to be the cauſe of the fertility which ariſes from the uſe of putrefying matters in the form of manure. The aerial acid or fixed air is likewiſe abſorbed by vegetables, when its quantity is ſmall. If the compoſition of fixed air be charcoal and vital air, as Mr. Lavoiſier has endeavoured to prove (ſee AIR FIXED), a large quantity muſt by ſome means enter into the ſtructure of vegetables. Chaptal has obſerved that fixed air predominates in the fungus and other ſubterraneous plants. But by cauſing theſe vegetables, together with the body upon which they were fixed, to paſs, by imperceptible gradations, from an almoſt abſolute darkneſs into the light, the acid very nearly diſappeared; the vegetable fibres being proportionally increaſed, at the ſame time that the reſin and colouring principles were developed, which he aſcribes to the vital air of the ſame acid. Senebier has obſerved that the plants which he watered with water impregnated with fixed air, tranſpired an extraordinary quantity of vital air, which likewiſe indicates a decompoſition of the aerial acid.

Light is almoſt abſolutely neceſſary to plants. In the dark they grow pale, languiſh, and die. The tendency of plants towards the light is remarkably ſeen in ſuch vegetation as is effected in a chamber or place where the light is admitted on one ſide; for the plant never fails to grow in that direction. Whether the matter of light be condenſed into the ſubſtance of plants, or whether it act merely as a ſtimulus or agent, without which the other requiſite chemical proceſſes cannot be effected, is uncertain. It is aſcertained that the proceſſes in plants ſerve, like thoſe in animals, to produce a more equable temperature, which is for the moſt part above that of the atmoſphere. Dr. Hunter, quoted by Chaptal, obſerved by keeping a thermometer plunged in a hole made in a ſound tree, that it conſtantly indicated a temperature ſeveral degrees above that of the atmoſphere, when it was below the fifty-ſixth diviſion of Fahrenheit; whereas the vegetable heat, in hotter weather, was always ſeveral degrees below that of the atmoſphere. The ſame philoſopher has likewiſe obſerved, that the ſap which, out of the tree, would freeze at 32°, did not freeze in the tree unleſs the cold were augmented 15° more.

The vegetable heat may increaſe or diminiſh by ſeveral cauſes, of the nature of diſeaſe; and it may even become perceptible to the touch in very cold weather, according to Buffon.

The compound principles obtained from vegetables are, 1. mucilage, 2. oil, 3. reſin, 4. fecula, 5. vegetable gluten, 6. ſugar, 7. acid, 8. alkali, 9. colouring matter, 10. pollen or wax, 11. wood, 12. mixed fluids diſtinguiſhed by the name of ſap, and 13. elaſtic fluids.

Mucilage appears to be the firſt ſtate of the alimentary juices in vegetables. It compoſes the baſis of moſt ſeeds and young plants, and greatly reſembles the mucilage of animals, and like that is moſt abundant in young ſubjects. It is ſometimes found entirely alone, as in mallows, linſeed, &c. ſometimes it is combined with matters inſoluble in water, which it keeps ſuſpended in the form of an emulſion. In other inſtances it is combined with oil. Not unfrequently with ſugar, as in the ſugar cane, Indian wheat, carrot, &c. It is alſo confounded with the eſſential ſalts with exceſs of acid, as in ſorrel, tamarinds, and the like. The characters of mucilage are inſipidity of taſte, ſolubility in water, inſolubility in ardent ſpirit, coagulation by the action of weak acids, the emiſſion of a conſiderable quantity of fixed air, at the ſame time that it becomes converted into coal without exhibiting any flame. Laſtly, it is capable of paſſing to the acid fermentation when diluted with water.

The formation of mucilage appears ſcarcely to demand the action of light, but its ſubſequent changes require the preſence of that agent. Dried mucilage is known in commerce by the name of gum, which ſee.

Oils are of two kinds, the fat or fixed oils, and the volatile or eſſential oils. See OIL.

Camphor may be referred to the eſſential oils, though in various particulars it differs from them remarkably. See the article.

A variety of reſins are uſed in the arts; for which ſee Resin, Balsams, and Gum Resin, alſo Gum Elastic.

Chaptal conſiders the fecula of vegetables as a ſubſtance in no other reſpect differing from mucilage than by its inſolubility in cold water. He accordingly conſiders the paſte or combination of flower with hot water as an abſolute mucilage. To theſe inductions various objections might be made; but as the facts lead us at preſent not much beyond conjecture, it is the leſs neceſſary to diſcuſs the matter. For the general properties of this ſubſtance ſee Bread, and Gluten Vegetable. It is one of the firſt articles of food for the greater number of animals.

For the properties of ſugar, ſee Sugar, and Acid of Sugar.

Many vegetables contain ſo large a proportion of acid, that its preſence is exhibited to the taſte and by other marks of diſengaged acidity. Theſe impure acids have been arranged according to various diviſions. They may be diſtinguiſhed either according to their diſtinctive characters, or the means by which they are obtained; and the latter, on account of our imperfect knowledge of the conſtitutional parts of the products of organized bodies, appears on the whole to be the moſt uſeful. Morveau in the Encyclopedie reckons two claſſes, namely, 1. ſuch acids as exiſt ready formed in the vegetable, whether in a ſtate partly diſengaged, as in ſour fruits, or diſguiſed by ſome neutralizing principle, as the acid of benzoin, and other balſams, and the half-ſaturated acids of tartar and ſorrel: 2. acids produced by chemical change in the conſtitution of the vegetable matter, whether by the acetous fermentation, or by abſtraction of the nitrous acid from ſaccharine or oily matters; or laſtly by deſtructive diſtillation.

The native vegetable acids are almoſt always more or leſs contaminated with mucilaginous and other matter. Theſe acids may in ſome inſtances be purified by ſtraining the juice carefully, inſpiſſating it either by heat or by freezing, and ſuffering the acid to cryſtallize. This proceſs, however, though the moſt ſimple and natural, is far from being eaſy, or in many inſtances practicable. The acids of tartar and of ſorrel cryſtallize in this way, but nevertheleſs with a portion of the vegetable alkali in combination. Later very ingenious proceſſes have been adopted by combining the acid with calcareous earth or ſome other ſuitable baſis, then waſhing off the mucilaginous fluid, and again diſengaging the acid by ſome other acid more ſtrongly attractive of the baſe. Inſtances of theſe proceſſes may be ſeen under the article Acid of Citrons. But I cannot avoid making an obſervation in this place, to expreſs my doubt whether it be the true vegetable acid in its original ſtate, which is extricated at this ſecond decompoſition. For we find that many acids are diſpoſed to alter their character by entering into combination. Thus in corroſive ſublimate and other compounds, the marine acid at the time of changing its ſtate of combination aſſumes the dephlogiſticated or aerated ſtate. When to the aerated marine acid is added the vegetable alkali, the firſt compound aſſumes a large proportion of the vital air ſuperadded to the acid, and forms a neutral ſalt containing an acid very highly aerated, while the remaining addition of alkali forms the common muriated vegetable alkali. So likewiſe the acids obtained from cryſtals of verdigris, or from foliated tartar, are not common vinegar, but the ſame acid in the aerated ſtate, called radical vinegar. It is probable that the vinegar aſſumed the vital air at the time of its entering into theſe combinations, and it is well known that it cannot diſſolve copper unleſs it be enabled to attract this principle.

The vegetable acids produced by fermentation are all comprehended under the denomination of vinegar. The ſeveral kinds of vinegar are found to differ from each other merely in ſtrength, and the greater or leſs abundance of foreign mucilaginous matter. See VINEGAR.

The abſtraction of nitrous acid by diſtillation from ſulphur, phoſphorus, and other combuſtible matters, for the purpoſe of communicating to them the portion of vital air which is requiſite to produce the acid ſtate, has been with great ſucceſs applied to vegetable and animal products by Scheele, Bergman, Berthollet, and other eminent chemiſts. See ACID OF SUGAR. When ſugar or other ſaccharine ſubſtances are acidified by repeated diſtillations of nitrous acid from them, the acid of tartar is formed; if the proceſs be continued farther, this acid becomes converted into acid of ſugar; a farther continuation produces vinegar. Several chemiſts who maintain the doctrine of phlogiſton, are of opinion, that the nitrous acid contributes nothing to theſe acids, but merely developes them from ſuperabundant oils and earthy matters. But when we reflect on the acidification of ſulphur and phoſphorus by this very treatment, which requires nothing but the addition of vital air, as far as we can perceive, to convert them into acids; it ſeems reaſonable alſo to infer, that vegetable matters are acidified in the ſame way, and that the differences of the acids do not conſiſt in a greater or leſs purification of the baſis, but in the proportion of vital air communicated to each.

Lemery in the Memoirs of the Royal Academy at Paris for 1721, quoted by Keir in his valuable Chemical Dictionary, article ACIDS VEGETABLE, gives a number of obſervations on the diſtilled acids from plants. He obſerves that all plants contain acid, but that the quantity is not to be eſtimated by the product yielded by diſtillation; becauſe it riſes from ſome plants in combination with volatile alkali, or with oil. Thus even ſorrel, which is known to contain much acid, yields when it is diſtilled alſo much volatile alkali, which combines with the acid, ſo that a leſs quantity of acid is in this caſe extricated than from plants which exhibit leſs indications of acidity. But if inſtead of diſtilling ſorrel or its juice in an open fire, either of theſe be firſt expoſed to the gentle heat of a water bath, the volatile alkali will be thus expelled, and the acid may be afterwards obtained much more copiouſly by applying a ſtronger heat, than if this latter degree of heat, which would have raiſed both principles at once, had been applied at firſt. Or again, if the ſorrel be macerated and ſuffered to ferment in water, the volatile ſalt will fly off, and the quantity of clear acid product by ſubſequent diſtillation will be proportionally increaſed. Many plants yield ſcarcely any acid by diſtillation, without a previous maceration and fermentation. Others again, as lemons, give little if any ſigns of volatile ſalt, and much diſengaged acid. He divides plants relatively to this ſubject into four claſſes. 1. Thoſe which give acid from the beginning to the end of the diſtillation, with little or no volatile ſalt. Such are rennet apples, and the pears called Martin ſec, or Franc royal. The ſecond claſs contains plants which yield more or leſs volatile ſalt, but not till the end of the diſtillation, whereas the diſengaged acid appears chiefly at firſt. Among this claſs are the cichoreum intybus Linn. celery, lettuce, fumitory, gentian-root, violets, peaches, roſes, polypody, rape-ſeed, melons, artichoke-bottoms, cheſnuts, apricots, red currants, elder-berries, and grape ſtones. The third claſs gives the volatile ſalt not only at the end but likewiſe at the beginning of the diſtillation, when the acid alſo ſometimes is expelled, and continues to diſtil till near the end, and then the volatile ſalt again appears. Of this claſs are common white ſuccory, carduus benedictus, red beets, ſpinach, cherries, onions, ſage, parſley, and many others. The fourth claſs gives much more volatile ſalt than the third, and this is diſtributed more uniformly and plentifully in all the different periods of the diſtillation. The acid alſo appears more or leſs in every period, but at laſt is quite overpowered and concealed by the quantity of volatile ſalt. Of this claſs are the leaves and ſtalks of the atriplex hortenſis, lamium album, parietaria, artichoke leaves, ſeeds of the wild gourd, wheat, barley, oats, and many others.

There are even ſome plants which give no traces of acidity in diſtillation; yet, as Lemery remarks, we muſt not thence infer that they contain none. For theſe plants yield a great deal of a volatile ſalt in which the acid is combined and hid. The ſame plants, previouſly fermented, yield acid in diſtillation.

The age of plants, and the difference of the parts of the ſame plant, affect the quantity of acid obtainable by diſtillation. Thus, in analyſing lettuce, he remarked, that younger plants give leſs acid than old ones, that the leaves give leſs acid than the ſtalks or roots, and that the juice yields leſs than the fibrous parts remaining after this juice had been expreſſed.

Every obſervation yet made on the acids obtained from organized ſubſtances by diſtillation, tends to ſhew that they are different from acids obtained by other means from the ſame ſubſtances. Little has been done to aſcertain the differences between theſe acids, but it is not probable on the whole that they poſſeſs any immediate identical principle or baſis. The alteration effected by the heat, excluſive of the empyreuma ariſing from burned oil, appears to be of the ſame nature as that effected by the nitrous acid, namely, a more perfect acidification. Keir, from whoſe dictionary I have extracted much of the preſent article, thinks that the action of fire decompoſes the native acids, and approximates, or perfectly converts them to vinegar; in which reſpect fire and the nitrous acid are ſimilar in their operation upon vegetable acids, all which by the continued abſtraction of the nitrous acid are changed into the acetous acid. An experiment of Mr. Weſtrumb*, who well underſtands this new branch of chemiſtry, relative to the examination of vegetable acids, proves in one inſtance this converſion of a native acid into the acetous, and gives probability to its generality. He analyſed a plant of the diadelphi claſs uſed for paſture, and from two pounds of the freſh herb, he procured twenty ounces of an empyreumatic acid liquor, which he afterwards rectified, and divided into two equal portions. On beginning to ſaturate one of theſe portions with alkali, he obſerved that a white precipitate fell, which was a true tartar. He then completed the ſaturation, and evaporated, by which he obtained 5½ drams of a deliqueſcent ſalt, which being mixed with vitriolic acid and manganeſe and diſtilled, yielded three drams of pure vinegar. This experiment ſhewed that the native acid of the plant is the acid of tartar, a ſmall part of which had been raiſed by the force of the heat unaltered, while the greater part of the acid is decompoſed by the fire, and changed into vinegar.

The ſame author is diſpoſed to conſider the acids produced from the animal and vegetable kingdoms, as not eſſentially diſtinct. He remarks that the acids of ants of milk, and of ſugar of milk, as well as the acid of amber, which is directly of mineral, though probably originally of vegetable origin, yield the ſame principles as vegetable acids when analyſed, and therefore may all be comprehended under one general claſs of acids of organic bodies. In this claſs he remarks, we ought certainly not to omit the permanently elaſtic fluid acid, called calcareous gas, or fixed air, being that to which all the other acids of this claſs are principally reſolved by analyſis. Laſtly the nitrous acid, generally ranked among the mineral acids, being actually produced from putrefied animal and vegetable ſubſtances, and the phoſphoric acid, are entitled by their origin, though not by their analyſis, to the ſame claſs of acids of organic bodies.

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* Weſtrumb. Abhandlungen, band 2. heft. 1. ſ. 350.

The following acids then compoſe this general claſs of organic acids:

Acid, acetous.
Acid of amber.
Acids of ants, ſilk-worms, and other inſects.
Acid of apples.
Acid of benzoin.
Acid gas, called calcareous gas, or fixed air.
Acid of camphor.
Acid of citrons.
Acid of corks.
Acids diſtilled from honey, from plants, from tartar, from ſugar, and from woods.
Acid of fat.
Acid of galls.
Acid of milk.
Acid, nitrous.
Acid, phoſphoric.
Acid, tartareous.
Acid, ſaccharine or oxaline.
Acid of ſugar of milk.

The German chemiſts have paid particular attention to the converſion of the acids of organic bodies into each other by ſuch management as the preſent ſtate of chemiſtry admits. Mr. Keir has collected in an alphabetic order, the principal facts relating to thoſe vegetable ſubſtances which have been examined with a view of inveſtigating their acids. At the ſame time that I copy in this place his excellent abridgment, the reader is informed that he will obtain much valuable information by recurring to the original.

Agave Americana, Linn. Mr. Hoffman of Weimar has examined a juice which ſweats from the calix of this plant, in order to know whether it was ſimilar in its contents to the juices of our indigenous plants, and he found that it contained the acids of tartar and of apples [*].

Aloes. Scheele obtained from an extract of aloes, by means of the nitrous acid, the acids of ſugar and of apples.

Apples. Scheele diſcovered in the juice of this fruit a new acid, to which he gave the name of acid of apples. See that article. By means of nitrous acid, Hermbſtadt obtained from this juice acid of tartar [†].

Berberry. The juice of this fruit contains acid of apples, not mixed with any acid of citrons, according to Scheele. Hermbſtadt ſays that it contains acid of tartar, and a peculiar acid, by which he means Scheele's acid of apples; and that when treated with nitrous acid, it yielded acid of ſugar. But Hoffman's experiments confirm Scheele's concluſion, that this fruit contains no other native acid than that of apples. By treating this acid with ſpirit of wine and manganeſe, he obtained an ether.

Bilberry (Vaccinium myrtillus). This fruit contains, according to Scheele, equal parts of acids of citrons and of apples.

Bramble (Rubus chamæmorus). The fruit contains acids of citrons and of apples, in nearly equal quantities, according to Scheele.

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[*] Crell, Annal. 1788, ſt. 1, p. 51.

[†] Hermbſtadt über die Natur der Grundſaure des Pflanzenreichs, § 22.

Camphor. By treating this ſubſtance with nitrous acid, Mr. Koſegarten[*] has effected a decompoſition, and obtained a peculiar acid ſubſtance. He diſtilled a mixture of one part of camphor and twelve parts of dephlogiſticated nitrous acid. Along with the red nitrous vapours an oil paſſed into the receiver, and much of the camphor was ſublimed. By repeating the operation eight times, the camphor was at laſt quite decompoſed, and ſilver white cryſtals of the form of parallelopipedons were produced. Theſe cryſtals were ſoluble in two hundred times their quantity of water, but unſoluble in ſpirit of wine; they exhaled a ſmell ſimilar to that of ſaffron; impreſſed on the tongue a ſour bitter taſte; reddened blue vegetable juices; neutralized alkalis, and therewith formed very ſoluble ſalts; diſſolved magneſia, iron, copper, zinc, biſmuth, arſenic, cobalt, manganeſe, and corroded tin and lead. They formed no precipitate when added to ſolutions of martial vitriol, or of calcareous earth in marine acid; but they precipitated a yellow ſalt from a ſolution of mercury in nitrous acid. From theſe properties it is evident that this ſalt was not the ſaccharine acid.

Cherry. Scheele found that the juice of cherries contained about equal parts of acids of citrons and of apples. Hermbſtadt ſays that he diſcovered acid of tartar in this juice[†]: but Weſtrumb, having repeated this examination, did not find any acid of tartar, but only acid of citrons; a part of which was diſengaged, another part was combined with calcareous earth, and another with fixed alkali[‡]. In Crell's Annal. for 1786, he ſays he found alſo acid of apples; but in his Treatiſe, publiſhed in 1787, he makes no mention of this acid. By means of nitrous acid, both Hermbſtadt and Weſtrumb obtained acid of ſugar.

Citrons. Scheele has diſcovered in the juice of lemons, as well as in many other vegetable matters, an acid poſſeſſed of peculiar properties, called by him acid of citrons. See that article.

Coffee. The infuſion of roaſted coffee, evaporated to the conſiſtence of a ſyrup, and treated with nitrous acid, gave the two acids of ſugar and of apples[‖].

Coloquintida. Scheele did not obtain any ſaccharine acid by treating this matter with nitrous acid.

Corks. Mr. Brugnatelli[§] has obtained a yellow acid by treating cork with repeated abſtractions of nitrous acid. This acid of corks unites with all alkalis and earths, forms with them neutralized ſalts, of which ſome are cryſtallizable, but are nevertheleſs apt in ſome degree to deliquiate. With fixed vegetable alkali it combines into a dark yellow maſs, which cryſtallizes in the cold in the form of ſmall needle-like priſms, ſoluble in water, vitriolic, nitrous, or marine acids, but unſoluble in vinegar or ſpirit of wine. This acid of corks has, like the ſaccharine acid, a ſtrong affinity to calcareous earth, which it ſeparates from lime water, and forms a grayiſh ſaline powder, unſoluble not only in water, but alſo in the acid of corks, although it diſſolves in marine acid. Laſtly, this acid of corks acts upon ſeveral metals, and exhibits different appearances, which according to Mr. Brugnatelli deſerve a more particular examination.

Cranberry (Vaccinium oxycoccos). This fruit, according to Scheele, contains acid of citrons alone.

Currants, red and white. Their juice gave the acid of citrons and of apples upon examination by Weſtrumb*. Hermbſtadt ſays that they contain acid of tartar, but Weſtrumb's experiments ſeem to be ſufficiently deciſive to the contrary.

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[*] De Camphora, Auctore D. A. J. F. Koſegarten, Goetting. 1785.

[†] Hermbſtadt, l. c. § 15.

[‡] Weſtrumb, Verſuche mit Pflanzenſaure, § 10. Abhandlung, band ii. heft 1.

[‖] Scheele, loc. cit.

[§] Crell, Annal. 1787, ſt. 2. ſ. 145.

Elder-berries. The fruit of the black elder was found by Scheele to contain ſcarcely any acid but that of apples.

Galls. A peculiar acid has been obtained from galls by Scheele. See Acid of Galls.

It is probable that from other aſtringent vegetable matters, eſpecially thoſe uſed in dyeing, acids might be obtained ſimilar to the acid of galls. Mr. Morveau has extracted a reſin from galls, which he ſuppoſes is the acidifiable baſis, which, together with pure air, forms the acid of galls. This acid, when purified, is ſaid to make a fine and durable ink. See Ink.

Geranium acidum. Cartheuſer † has procured ſmall acid-cryſtals from the juice of this plant. According to Hermbſtadt, this acid is the ſaccharine; for he ſays that the acid is different from the common acid of tartar, as the compound which it forms with calcareous earth, and which is very unſoluble, cannot be decompoſed by vitriolic acid; and further, that the cryſtals of this acid are ſimilar to the acid of ſorrel. For by adding to a ſolution of theſe cryſtals a ſolution of ponderous earth in vinegar, he obtained a precipitate, which, being digeſted with vitriolic acid, gave the ſaccharine acid, and vitriolated ponderous earth.

Gooſeberry. Scheele found in this fruit the acid of apples alone. Hermbſtadt indeed ſays that the acid of tartar is contained in the juice of gooſeberries; but at the ſame time he admits, that it cannot be exhibited by the uſual proceſs of ſaturating with chalk, and ſubſequent ſeparation by vitriolic acid; but that in order to procure acid of tartar from this juice, it is neceſſary previouſly to treat it with nitrous acid. But this latter acid is known to decompoſe vegetable juices, and to alter the modification of vegetable acids, ſo that not only the acid of tartar may be obtained by the action of nitrous acid from the juice of gooſeberries, but, by the further operation of the nitrous acid, the acid of gooſeberries may be changed into the acid of ſugar, as Hermbſtadt found. It does not then ſeem probable that the acid of tartar exiſts as ſuch in the unaltered juice of this fruit.

Grapes. The juice of grapes, with or without the aſſiſtance of fermentation, has been found to depoſit tartar, and conſequently to contain the acid of tartar united with fixed alkali.

Graſs-roots. Hermbſtadt ‡ expreſſed the juice of the roots of graſs (triticum repens), and obtained by evaporation and clarification a ſweetiſh extract, which being kept three months yielded ſaline cryſtals, ſoluble in water, and capable of giving an earthy precipitate when decompoſed by an alkali. Upon abſtracting nitrous acid from this ſalt, and adding to it a ſolution of calcareous earth in vinegar, a precipitate fell, which was found on examination to conſiſt of the acid of tartar ſaturated with lime. Hermbſtadt ſeems to conſider this experiment as ſhewing the exiſtence of acid of tartar in graſs-roots: but it ſeems rather to prove that this acid does not exiſt as ſuch there, until the action of the nitrous acid had developed it; for it is evident that the native cryſtals formed in the concentrated and clarified juice were not a tartareous ſalt of lime, being eaſily ſoluble in water.

Gums. Gum arabic, treated by Scheele with nitrous acid, yielded acids of ſugar and of apples.

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* Loc. cit. § 6.

† Cartheuſer, Samml. ſt. 6. ſ. 423.

‡ Loc. cit. § 23.

Gum tragacanth, during its ſolution in nitrous acid, let fall a white powder, which on examination was found to be the acid of the ſugar of milk. The ſolution alſo yielded the acids of apples and of ſugar *.

Haw (Cratægas aria). This fruit was found by Scheele to contain nearly equal parts of acid of apples and citrons.

Honey, like ſugar, yields by diſtillation an acid liquor, and, by treatment with nitrous acid, the acid of ſugar.

The diſtilled acid of honey has been ſaid to be capable of diſſolving gold: but this ſolution has not occurred to modern chemiſts. Perhaps it may diſſolve the precipitate of gold. Neither is it known to have any effect on ſilver, platina, or mercury. It diſſolves lead, and forms cryſtals with it. It attacks copper, which renders it green. It diſſolves tin and iron, with which latter metal it cryſtallizes. Mr. de Morveau has determined its affinities in the following order: Fixed vegetable alkali, fixed mineral alkali, ponderous earth, lime, magneſia, volatile alkali, earth of alum, metallic calces, water, alcohol.

Lemons. See Citrons.

Leontodon taraxacum. The expreſſed juice of the roots of this plant, treated with nitrous acid, gave indications of the preſence of the acid of tartar.

Manna, by treatment with nitrous acid, yielded acid of apples, and of ſugar †.

Mulberries. The juice of this plant contains, according to Hermbſtadt, the acid of tartar in a native ſtate. For, having clarified this juice and ſaturated it with chalk, he obtained a precipitate, which by adding vitriolic acid gave the acid of tar diſengaged. Angelus Sala obtained from this juice, by evaporation and cryſtallization, a cryſtallizable acid ſalt, which probably may have been a tartar ‡.

Oil of olives. By repeatedly and copiouſly abſtracting nitrous acid from this oil, Weſtrumb obtained a ſalt which ſublimed and cryſtallized.

Peruvian bark. An extract of this bark, treated with nitrous acid, yielded both the acids of apples and of ſugar.

Prunus ſpinoſa, et domeſtica. The fruit of theſe trees gave acid of apples, and little or no acid of citrons.

Prunus padus. This fruit gave acid of citrons, and little, if any, acid of apples §.

Poppy. The juice of poppies treated with nitrous acid gave acids of ſugar and of apples.

Raſpberries. The juice of this fruit gave the acids of citrons and of apples nearly in equal quantities, according to Scheele. But Hermbſtadt ſays, that by ſaturating this juice with chalk, and then ſeparating the earthy baſis from the compound by means of vitriolic acid, he obtained acid of tartar.

Rhapontic. From the expreſſed acid juice of the root of the rheum rhaponticum, Mr. Bindheim has extracted the acid of tartar, which in this juice ſeems partly in a diſengaged ſtate and partly combined with calcareous earth and with calx of iron. By treating this juice with nitrous acid, he obtained the acid of ſugar.

Rhubarb. The infuſion of this root being treated with the nitrous acid, gave the acids of ſugar and of apples. In this root, the acid of ſugar exiſts in

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* Scheele.

† Scheele.

‡ Oper. Angel. Salæ, p. 135.

‖ Crell, Chem. Ann. 1784, b. i. ſ. 229.

§ Hermbſtadt, ib. § 21.

a native ſtate, and the addition of nitrous acid is not eſſential to its production. For Scheele has ſhewn, that if a pound of Indian rhubarb be infuſed in hot water, a powder ſubſides, which by waſhing becomes white, in weight about $1\frac{1}{8}$ oz. that this powder is actually a ſaline compound, conſiſting of calcareous earth ſaturated with the oxaline acid, and is not a vitriolic ſelenite, as Model had affirmed.

Rhibes cynoſbati. The fruit, according to Scheele, contains the acid of citrons, with little or no acid of apples.

Salep. The root of ſalep treated with nitrous acid by Scheele, yielded the acids of ſugar and of apples.

Service (Sorbus aucuparia). The fruit of this tree was found by Scheele to contain acid of apples with little or no acid of citrons.

Solanum dulcamara. The fruit of this plant was found by Scheele to contain acid of citrons.

Sorrel (Rumex acetoſa). The expreſſed juice of the leaves of ſorrel, by evaporation yielded cryſtals of tartar; and by ſaturating this juice with chalk, and ſeparating the earth by means of vitriolic acid, an acid of tartar was obtained in a cryſtallized form. But although Hermbſtadt diſcovered no other acid in the juice of this plant than that of tartar, it is nevertheleſs frequently uſed, as well as the oxalis acetoſella, for preparing the ſalt ſold under the name of native ſalt of wood-ſorrel, the proper acid of which is the oxaline or ſaccharine.

Wood-ſorrel (Oxalis acetoſella). The acid contained in this plant is deſcribed under the article ACID OF SORREL.

Strawberry. The juice of ſtrawberries was found by Scheele to contain equal parts of the acids of apples and citrons.

Sugar. See Acid of Sugar.

Sugar of Milk. See Acid of Sugar of Milk.

Sumach (Rhus coriaria). Profeſſor Tromſdorf* extracted from the berries of ſumach a cryſtallizable acid ſalt, and determined ſome of its properties. His ſon has fully examined this ſalt, and has aſcertained it to be a true tartar†.

Tamarinds. Angelus Sala‡ and Baumé|| have each of them, by lixiviating the fruit of tamarinds, evaporation and cryſtallization, obtained an acid ſalt. This acid has been further examined by Scheele, Retzius, Hermbſtadt, Kemler and Weſtrumb. Scheele thought he perceived the preſence of his citron acid in this fruit; but the four latter authors affirm, that the acid is that of tartar. Weſtrumb particularly, who has written laſt on the ſubject, has given a very copious examination of this fruit, and ſeems to have aſcertained, that it contains the acid of tartar, alſo tartar itſelf, together with a mucilaginous and a ſaccharine matter§.

Vaccinium vitis idæa. The fruit of this plant contains the citron acid, according to Scheele.

Wood. It is well known that an acid liquor is obtained by diſtilling wood. Boerhaave has obtained acids from thoſe of box, guyac, juniper, and oak.

Mr. Goettling¶ has examined the acid diſtilled from the bark of the birch. By letting it remain at reſt during three months, he was able to ſeparate much of the oil that was mixed with it; and by ſaturating it with fixed alkali, he obtained a dark-coloured neutral ſalt, which he purified by fuſion, and by ſolution, and a ſubſequent evaporation. Upon diſtilling this purified neutral ſalt with vitriolic acid, he obtained an acid no longer empyreumatic, but poſſeſſed of an alliaceous ſmell. The academicians of Dijon have obſerved the reſults in diſtilling beech-wood. From 55 ounces of dry ſhavings they got 17 ounces of a rectified acid, which, when freed from oil of an amber colour, was of the ſpecific gravity, comparatively with that of water, as 49 to 48, and of ſuch a ſtrength, that one ounce of this acid required for its ſaturation 23½ ounces of lime-water.

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* Act. Acad. Elect. Mogunt. Erfurt, 1780.
† Crell, Annal. 1787. ſt. 5. ſ. 419.
‡ Oper. p. 134.
|| Elem. de Pharmacie, Paris 1762.
§ Einige Verſuche mit Pflanzenſauren, abh. ii. 1. 229.
¶ Crell's Journal Chem. 1779.

According to theſe chemiſts, the affinities of the acids of wood are in the following order: Lime, ponderous earth, vegetable fixed alkali, mineral fixed alkali, magneſia, volatile alkali, calces of zinc, manganeſe, iron, lead, tin, cobalt, copper, nickel, arſenic, biſmuth, mercury, antimony, ſilver, gold, platina, and earth of alum.

By digeſting beech-wood in nitrous acid, and by diſtilling the mixture, Hermbſtadt obtained a reſiduum which was found to contain acid of tartar. Goettling obtained acid of ſugar by treating wood with nitrous acid.

Much light has been thrown on the conſtitution of the vegetable acids by the converſions effected in Scheele's method of applying the nitrous acid. This ſubject has been very ſucceſsfully cultivated by Hermbſtadt and Weſtrumb, ſeveral of whoſe diſcoveries are contemporary, though unknown to each other. For the following extenſive and perſpicuous enumeration of facts, I am indebted to the dictionary of Keir.

1. The acid juice of lemons ſaturated with the abſorbent earth, called crabs-eyes, and preſerved in a bottle ſlightly ſtopped, with the addition of a little ſpirit of wine, gradually acquires the properties of vinegar, as Stahl has obſerved.

2. The acids of tartar and of milk digeſted, with the addition of water and ſome ſpirit of wine, during ſome weeks, were each of them converted into vinegar*. Crell remarks, that fixed and phlogiſticated airs were at the ſame time extricated.

Hermbſtadt ſucceeded in the converſion of the acid of tartar into the acetous without the addition of ſpirit of wine. He diſſolved four ounces of acid of tartar in ſixteen ounces of water, and kept this ſolution in a veſſel covered with paper in a warm place, during a ſummer. In three months the taſte of this ſolution was changed, and the air in the upper part of the veſſel was found to be fixed. In ſix months the liquor had the taſte of vinegar, and by diſtillation yielded good vinegar. In the reſiduum a ſalt was obſerved, which was not acid of tartar, nor altogether ſaccharine acid; although he remarks that in another inſtance, where the acid of tartar is united with a fixed alkali, and expoſed to fermentation, the ſaccharine acid is obtained. For a ſalt conſiſting of the ſaccharine acid and fixed alkali is found in caſks containing French-wine-vinegar, and is ſold as ſalt of wood-ſorrel, to which it is equivalent in its component parts, and in the proportion of theſe parts.

3. Eight parts of ſpirit of wine, eight parts of water, and one part of acid of tartar, mixed and digeſted during three months, with a very gentle heat, gave vinegar †.

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* Bergman, Opuſc. iii. 364.

† Weſtrumb über die Natur der Zuckerſaure, &c. ſ. 5.

4. Another experiment ſimilar to the laſt mentioned, except that the ſaccharine acid was uſed inſtead of the tartareous, ſucceeded alſo in the production of vinegar [*].

5. The acid of tartar diſtilled with vitriolic acid, gave an acid like the acetous. But vinegar was more perfectly produced, when to the mixture of tartareous and concentrated vitriolic acids ſome manganeſe was added ſucceſſively, until this addition no longer altered the colour of the liquor; which circumſtance indicated the dephlogiſtication of the acid of tartar, and the production of vinegar. During this operation much fixed air was produced [†].

6. Three parts of ſaccharine acid, two parts of manganeſe, and twelve parts of nitrous acid, gave by diſtillation vinegar, and ſome gas or air [‡].

7. By abſtracting nitrous acid from ſaccharine acid, a part of the latter acid was converted into vinegar; and this is the reaſon, as Hermbſtadt remarks, why, in the operation for preparing acid of ſugar, ſometimes only a ſmall quantity is produced of the ſaccharine acid, the remainder being changed into the acetous [||].

8. A mixture of two parts ſaccharine acid, four parts manganeſe, and three parts vitriolic acid, being diſtilled, yielded vinegar [§].

9. Upon diſtilling the acid of ſugar, with ſix times its quantity of vitriolic acid, vinegar, phlogiſticated vitriolic acid, and fixed air, were found in the receiver, and pure vitriolic acid in the retort [¶].

10. Acid of tartar is converted into acid of ſugar, by treatment with nitrous acid, and by further dephlogiſtication into vinegar.

11. One part of the acid of tartar, $1\frac{1}{2}$ part of manganeſe, and ſix parts of nitrous acid, gave by diſtillation vinegar and nitrous gas.

12. By diſtilling a mixture of two parts of acid of tartar, four parts of manganeſe, and three parts of concentrated vitriolic acid, vinegar was produced, and much fixed air was expelled.

13. By applying dephlogiſticated marine acid to the acids of tartar or ſugar, in the ſame manner as Weſtrumb had applied the nitrous acid, Hermbſtadt obtained vingar.

14. The acid of citrons was converted into the ſaccharine by Weſtrumb, in the uſual manner of abſtracting nitrous acid [**]. Scheele had tried this without ſucceſs, and gave, among the peculiar properties of this acid, that of not being convertible into the ſaccharine acid. Weſtrumb thinks that Scheele had uſed too much nitrous acid, and had thereby changed the acid of citrons into vinegar.

15. Scheele converted the acid of apples into the ſaccharine acid, by means of nitrous acid.

16. Hermbſtadt and Weſtrumb have changed into the acids of tartar, ſugar, or vinegar, the native acids of tamarinds, and many other fruits, &c. by means of nitrous acid.

17. Sugar, when treated with weak nitrous acid, gave acid of tartar, and with ſtronger nitrous acid, yielded acid of ſugar.

18. Bergman treated ſpirit of wine repeatedly with nitrous acid, and obſerved indications of ſaccharine acid. Weſtrumb by the ſame means obtained perfectly cryſtallized acid of ſugar; and when the dephlogiſtication was continued further, the acetous acid was produced.

[*] Weſtrumb über die Natur der Zuckerſaure, &c. [†] Ibid. [‡] Weſtrumb. Ibid. [||] Hermbſtadt, Grundſaure des Pflanzenreichs, &c. ſ. 37, 38, 39. [§] Hermb. Ibid. ſ. 41. [¶] Weſtrumb. loc. cit. [**] Crell, Annal. 1786, b. ii. ſ. 242.

19. Spirit of wine diſtilled with vitriolic acid and manganeſe yields, according to Hermbſtadt, vinegar.

20. By ſaturating the reſiduum in the preparation of dulcified ſpirit of nitre, with chalk, an unſoluble ſalt was formed, which being digeſted with vitriolic acid yielded a diſengaged acid of tartar.

21. Scheele diſcovered ſome acid of apples in the proceſs of preparing the ſaccharine acid from ſugar, by means of nitrous acid.

22. Hermbſtadt has procured vinegar from ſpirit of wine, without the aſſiſtance of acids, by means of cauſtic fixed alkali. He digeſted ſix ounces of cauſtic fixed alkali in two pounds of ſtrong ſpirit of wine, during two days, in a gentle heat, by which the ſpirit of wine acquired a dark brown colour. By diſtillation he obtained 1 pound 9 ounces of ſpirit, and he repeated the abſtraction ſeveral times, till the ſpirit was conſumed. The retort contained now a dark brown fluid, which was very cauſtic in taſte, and ſmelt of ſoap. Having diluted this liquor with water, filtrated the mixture through powdered glaſs, and evaporated it to dryneſs, he re-diſſolved it in water, added more vitriolic acid than was merely ſufficient for the ſaturation of the alkali, and diſtilled the mixture to dryneſs. The diſtilled liquor was of a peculiar ſmell and taſte, was free from vitriolic acid, and had a great reſemblance to the acetous acid, but was not completely vinegar. He ſaturated this acid liquor with fixed alkali, evaporated the ſalt to dryneſs, and digeſted it with ſpirit of wine, in order to ſeparate the acetous ſalts from any other, the former being ſoluble in ſpirit of wine. Accordingly he obtained an inſoluble reſiduum, which being put on hot coals, ſmelt like burnt tartar; and by abſtracting the ſpirit of wine, he got 4 ounces of a neutral ſalt, which had been diſſolved in the ſpirit, and which was found to be compoſed of acetous acid and fixed alkali; for upon adding to it vitriolic acid, and diſtilling the mixture, he obtained a true vinegar.

Although ſo many inſtances have been given of the converſion of the acid of ſugar, and all other vegetable acids, into the acetous; and of the acid of tartar, and all but the acetous, into the ſaccharine acid; yet no inſtance has ever occurred of any converſion in the contrary order; that is, of the acetous into any other acid, or of the ſaccharine acid into the acid of tartar, or any other vegetable acids, excepting the acetous. Weſtrumb tried to convert vinegar into ſaccharine acid by abſtracting it repeatedly from acid of tartar, but without any ſucceſs*.

The theory of the component parts of vegetable acids, that is to ſay, of thoſe baſes which in combination with vital air form acids, embraces the whole chemical theory of organized matter, into which much of conjecture muſt neceſſarily enter. When we conſider, that in every chemical proceſs with theſe ſubſtances, new combinations take place, at the ſame time that decompoſitions are effected; that many or moſt of the products aſſume the elaſtic ſtate, and conſequently are more difficultly weighed, meaſured, and examined; that the conſtitution of azotic or phlogiſticated air is ſtill a matter of doubt; that the baſis of fixed air, a fluid ſo univerſally produced or extricated, and proved by Lavoiſier to be acidified charcoal, is ſtill in ſome meaſure an object of controverſy; that inflammable air from organized beings is ſcarcely ever in an uncontaminated ſtate, and is beſides an element, the diſcuſſion of which embraces the great theory of the compoſition of water and acids in general; that every other principle obtained from theſe ſubſtances, water and charcoal excepted, is evidently of a compounded nature, and with a high degree of probability conſiſts of the preceding matters, with more or leſs of vital air in certain circumſtances;—when this rapid ſketch of the compoſition of organized bodies is reflected on, and extended in its various relations by the philoſophical chemiſt, it will be eaſily ſeen that much of conjecture muſt neceſſarily enter into this theory;—conjecture which, if luminous and clear, muſt be productive of bad conſequences as well as good. Hypotheſis well arranged ſerves to methodize facts and render them uſeful, to point out new experiments, and to fix the imagination upon thoſe habitudes of things which reſult from the exiſting diſcoveries: but on the other hand, as the infancy of any ſcience is neceſſarily attended with a ſcarcity of facts, and this ſcarcity can be no otherwiſe ſupplied by the author of a conjectural diſquiſition, than by hazarding bold inferences from what is already known, a large part of ſuch an hypotheſis muſt be doubtful, and this uncertainty will vitiate the general concluſions. If the human mind were capable of being ardent in the purſuit of truth, and at the ſame time cool and unprejudiced in the rejection of error as ſoon as diſcovered, we might with more ſafety indulge in this method of inveſtigation. But we inſenſibly become attached to theories in proportion to the labour of inveſtigation they have coſt us, and it ſeems for the moſt part an eaſier operation to add an argument or two in ſupport of the theory we have long dwelt on, than to weigh oppoſite arguments with impartiality, and reject the whole at once if the intereſts of truth ſhould require it. If it be true, as indeed it is, that the moſt candid and enlightened among men continually detect this proceſs of deluſion in their attempts to inveſtigate the ſecrets of nature; this conſideration muſt operate as a ſtrong reaſon why we ſhould patiently endure a ſtate of doubt ſo long as we do not poſſeſs clear indications of the truth; while, on the contrary, we ſhould employ our powers rather in deciding what are the moſt favourable departments for extenſive inveſtigation, than exert our ingenuity in completing the theory of the little we already know.

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* Crell, Ann. 1786, ſt. i. ſ. 64, and Weſt. Abhand.

Conſiderations of this nature render me unwilling to attempt a diſcuſſion of the theory of organized bodies. There is reaſon to think that their ſimple elementary parts are few, and that theſe parts, under peculiar circumſtances of expoſure, temperature and ſucceſſive operation, aſſiſted by the texture of the animal or vegetable itſelf, are combined together by one and one in various proportions, and under various degrees of ſaturation. For it is well known, that the power and probably the order of the elective attractions are affected by heat, and that the periods of ſaturation, as in tartarized vegetable alkali, and certain metallic ſalts, are capable of affording diſtinct compounds according to the proportions. It alſo appears more than probable, that triple combinations are afforded by the application of a ſimple principle to one of theſe binary combinations. And in theſe, not only the quantity of the principles and their union, but even the order of their arrangement, are affected by the manner in which the combination was brought about. Thus, as Keir very ingeniouſly remarks, the combination of alkali and oil may be brought about when the proportion of water to the pure ſalt is inconſiderable, or when the temperature of the mixture is elevated for a time; and this combination, denominated ſoap, is then capable of uniting with a large quantity of water. But if the ſame alkali and oil and water had been at firſt put together, the water and the ſalt would have united, and the oil would not have entered into combination. We may carry our reflections as to the compounded nature of organized matters to an extent perhaps not eaſily limited. In the concrete volatile alkali, we have azotic air, inflammable air, vital air, and charcoal. If the charcoal could be abſtracted, and an additional portion of azotic air added in a certain order of combination, we ſhould have nitrous ammoniac. For the vital air with the principle laſt added would form nitrous acid inſtead of fixed air, in which we aſſume the preſence of pure charcoal. Again, if the compoſition of water be admitted, and the laſt mentioned ſalt be diſſolved in that fluid, the reſult will be azotic air combined firſt with inflammable air; azotic air again ſeparately combined with vital air; and inflammable air combined with vital air. So that the whole number of principles in the ſolution of the ſalt will be no greater than before. If the nitrous ammoniac had been diſſolved in ardent ſpirit inſtead of water, and the ſpirit be admitted to conſiſt of fixed and inflammable air, the principles will ſtill be the ſame as before, excepting the addition of charcoal or the baſe of fixed air. From theſe inſtances it may be ſeen how much depends upon the order, time, ſituation and proportions of the component parts. And ſtill more, it will in a certain degree be perceived, how much the methods of chemical analyſis require to be improved, before we can aſcertain by any examination of the compound that order, arrangement, and relative diſpoſition of parts upon which ſo much of the immediate properties of the compounds depends.

For an extended view of this ſubject, the reader may have recourſe to the article Acids Vegetable of the larger dictionary of Keir, the numerous writings of Lavoiſier, and the antiphlogiſtic chemiſts.

The alkalis afforded by the incineration or other management of vegetable matters have already been abundantly treated of under their reſpective heads. See Alkalis, alſo Pot-ash, and Pearl-ash.

The colouring matters of vegetables are objects of the art of dyeing. Theſe are changed by combination with acids, alkalis, and metallic calces. See Dyeing. The colouring principle is found, according to Chaptal, in four ſtates of combination: 1. with the extractive principle; 2. with the reſinous principle; 3. with a fecula; and 4. with gum.

When the receptacle of the colour is of the nature of extracts, water takes up the whole, as may be remarked in logwood, turnſole, madder, cochineal, and the like. The colour given to any ſtuff by immerſion in this aqueous ſolution, is a mere ſtain capable of being waſhed out. The art of the dyer conſiſts in impregnating the ſtuffs with ſome other principle diſpoſed to combine with the colouring matter, and form an inſoluble compound with it. This principle is called the mordant. If the reſult or compound of the mordant and the colouring matter be totally or nearly inſoluble in thoſe fluids which are likely to be applied to the ſtuff, and the affinity of this inſoluble matter to the ſtuff itſelf be ſuch as to produce a firm adheſion between them, the tinge or ſtain will be a good dye.

Thoſe colours which are ſoluble in ſpirit of wine only, on account of their reſinous baſis, are uſed only in pharmaceutical tinctures, or in the art of dyeing ribbands.

Of colouring matters combined with a fecula, indigo and archil, are leading inſtances; for which conſult the articles reſpectively.

Such colouring matters as produce a firm dye by treatment with mere water, are ſuppoſed to be combined with gum reſin, the reſinous part of which is concluded to act the part of a mordant.

The pollen or fecundating powder of vegetables differs very little from wax;

and this laſt is with conſiderable probability inferred to conſiſt of a fat oil hardened by the combination of vital air.

Of the ligneous portion of vegetables, or the vegetable fibre, we find but little in the way of reſearch among chemical writers. Its moſt evident character is inſolubility in water and almoſt every other menſtruum. Its expanſion and contraction by change of temperature are likewiſe leſs than thoſe of any other known ſubſtance. It appears however, that its texture or firmneſs is in ſome meaſure altered by heat, attended with moiſture, as is ſhewn in the common inſtance of bending timber for ſhip-builders' uſe. The vitriolic acid applied to wood is decompoſed. The wood is brought nearer to the ſtate of coal, and volatile vitriolic acid flies off. The nitrous acid is decompoſed upon wood, nearly in the ſame manner, but appears more diſpoſed to produce the acid ſtate, as is obſervable when it is applied to cork. Dry wood is ſo little altered by expoſure to the atmoſphere, that we know of no proceſs of decompoſition or deſtruction which it undergoes in this expoſure, excepting from the action of inſects which feed upon it. Chaptal is of opinion, that its component parts are the baſis of mucilage, hardened by a greater quantity of vital air in the fixed ſtate. For diluted nitrous acid digeſted upon fecula converts it into a ſubſtance reſembling wood; and he has likewiſe obſerved, that thoſe fungi which grow in ſubterraneous places void of light, and are reſolved into a very acid water when left in a veſſel to decompoſe, will acquire a greater quantity of the ligneous principle, if carefully removed ſo as to vegetate in the light, by which management they are at the ſame time deprived of their acid principle.

Wood conſtantly immerſed in water, appears to endure at leaſt as well as in the air; but the alternate action of air and water ſpeedily deſtroys wood by a proceſs called rotting, which is apparently of the ſame nature as the change produced by the action of nitrous acid.

It ſhould ſeem as if the combuſtion of linen and other ligneous matters cloſely packed together, with a certain proportion of water or oil, as in hay-ſtacks, or the inſtances quoted at our article Pyrophori, might ariſe from the tranſition of vital air frequently perhaps afforded by the wood itſelf.

Chaptal directs our attention to the tranſition of mucilage to the ſtate of wood in the growth of vegetables. The cellular envelope which is immediately covered by the epidermis exhibits nothing but mucilage and glands; but by degrees it hardens, forms a ſtratum of the cortical coating, and at laſt concludes by becoming one of the ligneous rings.

We obſerve this tranſition in certain plants which are annual in cold climates, and vivacious in temperate climates. In the former they are herbaceous, becauſe the periodical return of the cold weather does not permit them to develope themſelves. In the ſecond they become arboreſcent, and the progreſs of time hardens the mucilage, and forms ligneous coatings.

The induration of the fibrous part may be accelerated by cauſing the air and light to act more ſtrongly upon it. M. de Buffon has obſerved, that when a tree is deprived of its bark, the external part of the wood which is expoſed to the air acquires a conſiderable degree of hardneſs; and trees thus prepared form pieces of carpentry much more ſolid than thoſe which have not undergone ſuch preparation.

It is probably owing to the large quantity of pure air with which the fibrous matter is loaded, that it is not diſpoſed to putrefy; and it is in conſequence of this moſt valuable property of not being ſubject to corruption, that arts have been invented for clearing it of all fermentable principles of the vegetable kingdom, to obtain it in its greateſt purity in the fabrication of cloths, paper, &c.

The mixed fluids of plants conſiſt in general of oils, mucilages, ſalts, and other principles, together with water, much more confuſed when mechanically extracted by art, than when ſeparately exiſting in the veſſels of the plant. Every reader will readily bring to mind the numerous vegetable products employed as articles of food, or in the manufactures. And theſe reſpectively compoſe ſo large a part of our work, that an enumeration would be of no apparent utility.

The elaſtic fluids extricated from vegetables have likewiſe claimed much of our attention. In the deſtructive diſtillation of vegetable matters, the vaporous and elaſtic products commonly are water, acid, oil, fixed air, and inflammable air. The quantity of this laſt product is very conſiderable; and though it holds ſo much fixed air in combination, that it is not more than five times as light as the air of the atmoſphere, yet it has been recommended by Morveau as a cheap material for inflating aeroſtatic balloons.

VEGETATION, SALINE. The cryſtallization of ſalts in a fluid is uſually aſcribed to a diſpoſition of the parts to come together in a certain order, dependent on a principle ſomewhat reſembling that polarity which produces a ſymmetrical arrangement in particles of ſteel in the vicinity of a magnet. But there ſeems to be ſome other principle concerned in cryſtallization, which cauſes the whole ſtructure or group of cryſtals to occupy more ſpace than before, and in a certain looſe mode of expreſſion may be called a diſpoſition in the parts to recede from each other. Thus a drop of water in a very cold atmoſphere not only freezes, but puts forth rays in the form of a ſtar, and ice is univerſally leſs denſe than water. So likewiſe in the tranſition of metals from the fluid to the ſolid ſtate, they not only cryſtallize internally, but part of the cryſtals protrude themſelves above the common ſurface, ſo as to deſtroy its uniformity, and produce thoſe figures with which the imagination of the alchemiſts was ſo much ſtruck. Saline bodies, of which the cryſtallization forms one of the moſt common, but by no means the leaſt intereſting of the effects of chemiſtry, likewiſe exhibit this appearance. For the ſaline matter of the ſolutions ſlowly creeps up the ſides of the veſſels, paſſes over the rim and down the external ſurface.

Mr. Chaptal has given us a good memoir on this ſubject in the Journal de Phyſique for October 1788, intitled Obſervations on the Influence of the Air and Light upon the Vegetation of Salts.

In the operations in the large way of his manufactory of medical and chemical products, he often obſerved that ſalts, particularly the metallic, vegetated on the ſide moſt expoſed to the light, and the frequency of the effect induced him to make ſome direct experiments on the ſubject. For this purpoſe he took ſeveral capſules of glaſs, and covered the half of each, as well above as below, with black taffetas. At the ſame time he prepared ſolutions of almoſt all the earthy, alkaline or metallic compound ſalts in diſtilled water, at the temperature of the atmoſphere. Theſe capſules were placed on tables in a well cloſed chamber which had no chimney, and of which the doors and windows were carefully ſtopped up, in order that the evaporation might not be haſtened by any agitation of the air. Reflected light, by which I underſtand the light from the clouds, was admitted through a ſmall aperture in one of the window-ſhutters. By this management, as well as the diſpoſition of the capſules, one half of each of their reſpective cavities received light from the aperture, and the other was almoſt perfectly in darkneſs. The reſpective ſolutions were then carefully poured into the capſules by means of a funnel reſting on the middle of the bottom, ſo that the border of the fluid was neat and uniform, without any irregularity or drop of the fluid falling on the bare ſurface of the glaſs.

Upwards of two hundred experiments were made with variations of the principal trials, ſo as to leave no doubt with regard to the conſtancy of the reſults. The moſt remarkable fact is, that the vegetation took place on thoſe ſurfaces only which were illuminated. This phenomenon was ſo ſtriking in moſt of the ſolutions, that in the ſpace of a few days, and frequently even within one ſingle day, the ſalt was elevated ſeveral lines above the liquor upon the enlightened ſurface, while there did not appear the ſmalleſt cruſt or edge on the dark part. Nothing could be more intereſting than to obſerve this vegetation, projecting frequently more than an inch, and marking the line of diſtinction between the illuminated and dark parts of the veſſel. The vitriols of iron, of zinc, and other metals, more eſpecially preſented this appearance. It was generally obſerved, that the vegetation was ſtrongeſt towards the moſt enlightened part.

This phenomenon may be rendered ſtill more intereſting by directing the vegetation at pleaſure towards the different parts of the veſſel. For this purpoſe, nothing more is required than to cover the ſeveral parts in ſucceſſion. For the vegetation always takes place in the enlightened part, and quickly ceaſes in that which is covered.

When the ſame diſſolution has ſtood for ſeveral days, the inſenſible evaporation gradually depreſſes its ſurface, and a cruſt or edge of ſalt is left in the obſcure part. But the ſalt never riſes, or at leaſt very imperfectly, above the liquor, and cannot be compared with the true vegetation.

When ſalts are ſuffered to vegetate in this manner, the ſpontaneous evaporation of the fluid affords very few cryſtals. All the ſaline matter extends itſelf on the ſides of the veſſel.

This property of vegetation differs greatly in the ſeveral ſalts. Thoſe which are deliqueſcent, moiſten the ſides of the veſſel to a ſmall diſtance above the edge of the fluid, but form neither cruſt nor ramification. Thoſe ſalts which are leaſt deliqueſcent, appeared in general to vegetate the moſt ſpeedily, and to the greateſt height; and among theſe the metallic ſalts appeared to have the pre-eminence.

Very ſingular varieties are obſervable in the form affected by each ſalt in its vegetation. In ſome, among which are the vitriols of iron, copper, zinc, and Glauber's ſalt, a cruſt is formed which ſwells or bliſters in proportion to its growth, becomes reduced into leaves, and forms either a ſeries of plates oppoſed to each other, or bliſters of no determinate form.

In other ſalts, needles are obſerved to iſſue from the liquor along the ſides of the veſſel, and by croſſing each other form a very curious kind of net-work. The ſalt of tin preſented our author with one of thoſe very ſingular appearances. By the too rapid action of aqua regia upon tin, a whitiſh magma was obtained, which he diluted with water and filtered ſeveral times. The ſolution was always whitiſh, and in this ſtate was ſubmitted to experiment. Some days afterwards, a ſaline cruſt was perceived on the border of the enlightened part of the veſſel. This cruſt increaſed daily, and appeared to take root in the liquor by a multitude of oblong pyramidal cryſtals which entered into the ſolution. The cryſtals, when once the depreſſion of the fluid had left their extremities bare, joined together by tranſverſal lines, and aſſumed the moſt beautiful yellow colour.

It frequently happens that the lines or cryſtals diverge from a common centre, and form the moſt beautiful feathers. This appearance was preſented by the acetous ſalt of lime.

The vegetation in many inſtances forms a thin even covering on the ſides of the veſſels. Alum, nitre, and ſea ſalt preſented this appearance.

The vegetation of certain ſalts may be favoured by the addition of an exceſs of acid. Vitriolated tartar is of this kind. It then forms white feathers on the ſides of the glaſs and the ſurface of the liquor, which ſometimes entirely cover it, and crown the borders of the veſſel in the moſt agreeable and ſtriking manner. A large ſwan's feather does not exceed theſe vegetations either in whiteneſs or beauty. Chaptal obtained ſome which were eight or ten inches in diameter. They ſoon effloreſce if the veſſel be not ſupplied with a due quantity of the ſolution, becauſe this vegetation draws up a large quantity of fluid in a ſhort time.

This chemiſt obſerved, that when the acid ſolution was charged with vitriolated tartar in exceſs by the aſſiſtance of heat, the ſalt is precipitated in fine cryſtals of vitriolated tartar at the ſimple temperature of the atmoſphere, and theſe cryſtals have no exceſs of acid. But if diſtilled water be ſaturated with vitriolated tartar at the temperature of the atmoſphere, and the ſame exceſs of acid be added, the ſalt afforded by ſpontaneous evaporation will have an exceſs of acid. The form of theſe cryſtals was conſtantly that of a ſix ſided flattened priſm, terminating in two facets. From theſe phenomena Mr. Chaptal was led to believe, that light is the ſole determining cauſe of vegetation, but ſubſequent experiments convinced him that air is the principal agent.

1. A ſolution of copperas in a capſule well enlightened and covered with a clean glaſs, afforded no appearance of vegetation.

2. A ſimilar ſolution left in a very obſcure place, vegetated in that part only which was uncovered, but more ſlowly than when a greater quantity of light was admitted.

3. The ſolution placed in a well cloſed bottle, reverſed upon water and expoſed to day-light, does not vegetate.

4. The vegetation takes place ſooner in a very open veſſel, ſuch as a cup, than in a cylindrical veſſel; ſooner in this laſt than in an uncorked bottle; and in cloſed veſſels not at all.

If a glaſs funnel be reverſed in a capſule containing a ſaline ſolution, the vegetation takes place on the external ſurfaces, but ſcarcely at all within. It appears therefore that the acceſs of air and its free circulation are peculiarly advantageous to the production of this appearance.

It muſt be obſerved that the nature of the veſſels is not a matter of indifference in theſe experiments. Glaſs is very proper, and metals much leſs ſo. But Chaptal remarks, that the phenomenon does not ariſe from an affinity between the veſſel and the fluid, becauſe if ſo the expoſure and light would not be required.

Similar experiments on the vegetation of ſalts which effloreſce on the ſurface of earths, afforded reſults of the ſame kind. He affirms that they all depend on the action of the air, ſlightly aſſiſted by the concurrence of light. The contact or privation of theſe agents either favours or interrupts the effect. The nitrous, aluminous or vitriolic earths exhibit ſtriking effects of this kind. Their vegetations are often five inches in length.

The author is averſe to entering into conjecture relative to this appearance. He only demands whether it be a kind of affinity between the air, light and ſaline ſubſtances, which elevates the latter contrary to their gravitation? Or is it, he demands, a virtue truly vital which the contact of air determines and foments? It cannot be denied, but that much of obſcurity attends the conſideration of what happens among the particles of matter, and that the caution of this author is to be applauded for encouraging a diſpoſition to generalize the facts, rather than to multiply ſpeculations. I ſhall likewiſe therefore avoid any attempt at particular explanation, but the following facts ſeem to throw ſome light on the ſubject.

Cryſtallization, properly ſo called, is an effect of the mutual tendency of the parts of a body to come together, and takes place whenever the quantity of ſolvent becomes diminiſhed. See Crystallization. When the quantity of ſolvent is ſlowly diminiſhed, and external agitation prevented, the cryſtals are large and of a determinate figure; but in oppoſite circumſtances they are ſmall, irregular, and in confuſed groups. The preſence of light is found to interrupt cryſtallization nearly in the ſame manner as agitation would have done. The vegetation of ſalts conſequently appears to be of a diſtinct nature in certain reſpects from cryſtallization within a fluid. The cryſtallization which approaches moſt nearly to vegetation is effected when a thin covering of ſaline ſolution is ſpread out upon a pane of glaſs. In this caſe the attractions of the particles of the ſalt to each other, are all nearly in the ſame plane, and may therefore, notwithſtanding the ſpeedy evaporation, be expected to produce effects more ſymmetrical than when a much greater thickneſs of fluid is ſaid to cryſtallize. The manner in which the air acts is a ſubject of no difficulty; ſince it favours the cryſtallization by abſtracting the water. But the agency of light in the experiments of Mr. Chaptal is much more obſcure. Experiment leads us no farther than to aſſert that it ſingularly favours the aſſumption of the elaſtic ſtate, inſomuch that principles which in the dark would have remained united, become ſeparated by the agency of light which gives elaſticity to one or more of them. This is ſeen in the decompoſition of nitrous acid in half-filled veſſels; the extrication of vital air from vegetables, and other ſimilar effects. Simple evaporation is likewiſe ſo far favoured or modified, that the fluid in a cloſed veſſel or bottle partly filled with water or ſaline ſolution, riſes and is condenſed in drops on the ſide neareſt the light. This fact helps us forward in a certain degree. For the light muſt raiſe part of the ſolution, whether merely aqueous or ſaline, on that ſide of the veſſel which is moſt illuminated; and when once the ſurface is wetted, the ſaline ſolution will riſe to a certain height by coheſive attraction. In this ſituation, it becomes the film of liquid expoſed on a pane of glaſs. Speedy evaporation affords cryſtals more or leſs regular, on the ſame principle as ramified cryſtals are produced in the inſtance laſt mentioned. The interſtices between theſe minute cryſtals are capillary tubes, which carry up more of the ſaline ſolution, which is diſtributed by the agency of light as before, and the vegetation goes on. Hence it appears, that a want either of light or of air muſt ſuſpend the proceſs, ſince it is in vain that the light is found to ſpread the fluid over the ſurface in a cloſed veſſel, if there be not enough of air in ſucceſſion to cryſtallize the ſalt by evaporation. The ingenious author remarks, that the veſſels themſelves are not indifferent as to the production of this phenomenon. He thinks that it cannot ariſe from an affinity between the ſaline ſolution and the matter of the veſſel; but the reaſon he gives for this opinion is far from being concluſive. For the abſolute neceſſity of two agents in the production of a phenomenon, does not exclude a third efficient cauſe. If three cauſes be jointly neceſſary, the abſence of any one of them will be incompatible with the production of the effect. I am diſpoſed however to think, that the different properties of the veſſels in this behalf ariſe either from their nature as conductors of heat or electricity, or elſe their tranſparency. It is well known from the numerous inſtances adduced by Muſchenbroek, that the dew falls plentifully upon diſhes of certain materials, and avoids others. The exhalation and condenſation here obſerved as a conſequence of the agency of light, will in all probability be modified by the cauſe which affects the diſtribution of the dew: what that cauſe is muſt be left to future reſearches.

VEINS. The ores of metals are frequently found to fill certain clefts in mountains. Theſe maſſes, when they run out in length, are called veins. Inconſiderable veins which diverge from the principal are called ſlips; and ſuch maſſes of ore as are of conſiderable magnitude but no great length, are called bellies, or ſtock works. See METALS, METALLURGY, and ORES.

VENUS. The name of the planet Venus has been given to copper, but it is now ſcarcely ever uſed. The chemical character or ſign of copper is the ſame as the aſtronomical character of the planet. See the plate of Chemical Signs.

VERDIGRISE is copper corroded, and reduced to a very beautiful green ruſt, by a vinous acid. This matter, which is uſeful to painters, is conveniently manufactured at Montpellier; the vines of Languedoc, of which that city is the capital, being very proper for this preparation.

The following proceſs for making verdigriſe is deſcribed by Mr. Monet of the Royal Society of Montpellier, and is publiſhed among the Memoirs of the Academy for the years 1750 and 1753.

Vine ſtalks well dried in the ſun are ſteeped during eight days in ſtrong wine, and afterwards drained. They are then put into earthen pots, and upon them wine is poured. The pots are carefully covered. The wine undergoes the acetous fermentation, which in ſummer is finiſhed in ſeven or eight days, but requires a longer time in winter, although this operation is always performed in cellars. When the fermentation is ſufficiently advanced, which may be known by obſerving the inner ſurface of the lids of the pots, which during the progreſs of the fermentation is continually wetted by the moiſture of the riſing vapours, the ſtalks are then to be taken out of the pots. Theſe ſtalks are by this method impregnated with the acid of the wine, and the remaining liquor is but a very weak vinegar. The ſtalks are to be drained during ſome time in baſkets, and layers of them are to be put into earthen pots with plates of Swediſh copper, ſo diſpoſed that each plate ſhall reſt upon, and be covered with layers of ſtalks. The pots are to be covered with lids, and the copper is thus expoſed to the action of the vinegar, during three or four days or more, in which time the plates become covered with verdigriſe. The plates are then to be taken out of the pots, and left in the cellar three or four days; at the end of which time they are to be moiſtened with water, or with the weak vinegar above mentioned, and left to dry. When this moiſtening and drying of the plates has been thrice repeated, the verdigriſe will be found to have conſiderably increaſed in quantity, and it may then be ſcraped off for ſale.

A ſolution or eroſion of copper, and conſequently a verdigriſe, may be prepared by employing ordinary vinegar inſtead of wine, as is directed in the above proceſs. But it would not have the unctuoſity of ordinary verdigriſe, which quality is neceſſary in painting. Good verdigriſe, according to Macquer, muſt be prepared by means of a vinous acid, or ſolvent half acid and half ſpirituous. Accordingly the ſucceſs of the operation depends chiefly on the degree of fermentation to which the wine employed has been carried: for this fermentation muſt not have been ſo far advanced, that no ſenſibly vinous or ſpirituous part remained in the liquor.

Verdigriſe is uſed for painting, as it furniſhes a fine green colour, when mixed with oil. It enters alſo as an ingredient into ſeveral plaiſters and ointments. In chemiſtry, verdigriſe is uſed for the extraction of radical vinegar, and for the preparation of cryſtals of verdigriſe, or of Venus.

The above is copied from Macquer. Chaptal informs us, that the fabrication of this article was till lately confined to Montpellier, from a prejudice that the cellars of that city alone were proper for the operation. His account of the manufacture is leſs ample than the foregoing, but in effect the ſame. This article is is alſo made at Grenoble, where ready made vinegar is uſed and ſprinkled on plates of copper. This verdigriſe contains one ſixth part leſs of copper than that of Montpellier, and has not the empyreumatic ſmell of the latter. The vinegar it affords by diſtillation is likewiſe ſtronger and in greater plenty. Whence he concludes, that part of the calx of copper in this compound is really diſſolved, and brought into the ſaline ſtate.

VERDITER is a blue pigment, obtained by adding chalk or whitening to the ſolution of copper in aqua fortis. It is prepared by the refiners, who employ for this purpoſe the ſolution of copper, which they obtain in the proceſs of parting, by precipitating ſilver from aqua fortis with plates of copper. See Parting. It is ſaid, that a fine coloured verditer cannot be obtained from a ſolution of copper prepared by diſſolving directly that metal in aqua fortis; and that the ſilver is neceſſary. We know that it is actually made of a good quality by the refiners only. Dr. Merret ſays, that it is prepared in the following manner: A quantity of whitening is put into a tub, and upon this the ſolution of the copper is poured. The mixture is to be ſtirred every day for ſome hours together, till the liquor loſes its colour. The liquor is then to be poured off, and more ſolution of copper is to be added. This is to be repeated till the whitening has acquired the proper colour. Then it is to be ſpread on large pieces of chalk, and dried in the ſun.

We have two kinds of verditer in the Engliſh market: the one, called refiners verditer, has the form of a very ſoft impalpable powder, and poſſeſſes a ſtronger body of colour than the other. The other verditer has the form either of hard irregular lumps or powder, in which laſt ſtate it is much harſher to the feel, and is by no means ſo readily diffuſible in water. The beſt verditer is, as I underſtand, made by the refiners, not becauſe their ſolution of copper poſſeſſes any peculiar advantage over any other nitrous ſolution, but becauſe they obtain it more cheaply than if the acid had not been already paid for in their proceſs of parting. The value of the article is not ſufficient to pay for the expence of a direct ſolution in this country. Common verditer is made from the vitriol of copper, which may be had at a reaſonable rate from the manufacturers at Sheffield and Birmingham. I am not acquainted with that part of their manufactories which afford it, but underſtand that it is not produced in a direct way, but from clippings of metal or other ſavings. It is frequently contaminated with iron. The copper of a ſolution of this vitriol is precipitated by an addition of lime in the making of common verditer. Whiting will not effect a ſeparation. The precipitate afforded by the lime is blue, but requires ſome management as to the quantities of water as well as of the other principles, and the method of the drying, to produce the beſt effect. The flintineſs or harſhneſs of the common verditer, ariſes no doubt from an admixture of ſelenite; whereas in the refiners venditer little of lime is found, becauſe the nitrous ſalt of lime is very ſoluble in the water. If the object ſhould be found of ſufficient commercial importance, it is probable that the blue calx of copper in verditer might be obtained by an indirect proceſs of tranſferring nitrous acid to the metal. Thus, if the ſolutions of nitre and of vitriol of copper be mixed, the alkali unites with the vitriolic acid, and vitriolated tartar falls down, if the quantity of water be not conſiderable, at the ſame time that the nitrous acid transferred to the copper remains in ſolution. Other methods of decompoſition might be eaſily pointed out, but every thing of this nature muſt be referred to the teſt of experiment. For in ſome inſtances, triple compounds are formed where perfect decompoſition was expected, and in moſt inſtances the complete edulcoration of the product is required, and many apparently minute circumſtances muſt be inveſtigated and attended to, where ſo delicate a thing as the colour of a metallic calx is the object aimed at. The refiners verditer is more than twice as dear as the common. Both are uſed in water colours only, chiefly by the paper ſtainers. It is ſaid that the greater intenſity of colour added to the facility with which it may be uniformly ſpread over any ſurface, affords the advantage even of cheapneſs to the refiners verditer; but the laſt mentioned quality is communicated to common verditer, by ſteeping it for ſeveral days in water before it is uſed.

In the 13th volume of the Annales de Chimie, is inſerted a chemical examination of verditer, by Pelletier, extracted from a memoir read to the Academy of Sciences. After giving a ſhort hiſtory of the article according to the uſual and excellent cuſtom of the French writers, he proceeds to relate his own experiments. He uſed that article which we call refiners verditer. 1. Verditer was totally diſſolved in the nitrous and marine acids, and fixed air was ſeparated with efferveſcence. 2. The vitriolic acid attacked verditer with ſtrong efferveſcence, ſo as almoſt to throw the mixture out of the matraſs. The ſolution was not perfectly clear. After evaporation to dryneſs, diſtilled water was added. It took up the whole, which was found to be ſelenite and vitriol of copper. The former was firſt ſeparated by evaporation, and afterwards the latter. From theſe products it was aſcertained that a hundred grains of the verditer contained ſeven grains of lime, and fifty grains of pure copper. The inferior verditers were found to contain more lime and leſs copper, the quantity of the former in ſome amounting to near 14 grains. Their colour was accordingly leſs intenſe. 3. Volatile alkali takes up the copper from verditer, and leaves a ſmall portion of mild calcareous earth. But the numerical reſults of this experiment could not be depended on, becauſe the chalk exiſts in the verditer ſo minutely divided, or perhaps becauſe it unites with the compound in the ſolution, and cannot therefore be well ſeparated. 4. By diſtillation in the pneumatic apparatus, by a gradual heat, a loſs of accurately two thirds of its weight was experienced. The volatile product was almoſt totally air, ſoluble in water, converting tincture of turnſole to a red, and precipitating lime water. It was therefore fixed air. A few drops of water were perceived in the neck of the retort, which being deducted by eſtimate from the weight of the elaſtic product left 30 per cent. of fixed air. 5. The reſidue of this diſtillation was divided into two parts, and reduced with a proper quantity of black flux and charcoal with common ſalt. The quantity of copper in one of theſe reductions proved to be 49 parts in the hundred of the original weight of verditer, and the other proved to be $49\frac{1}{2}$. With a ſmall allowance therefore, for loſs and inaccuracy, this reſult may be taken as a confirmation of the humid analyſis, which gave 50. 6. The quantity of vital air in the calx was aſcertained by inference from the preceding facts. From a hundred parts the products were 30 fixed air, $3\frac{1}{3}$ water, 7 lime, and 50 copper. In order to complete the hundred parts, it is neceſſary to add $9\frac{2}{3}$. This will be the weight of vital air. With a view to aſcertain more perfectly that vital air is really contained in verditer, a certain quantity was diſtilled till it afforded no more fixed air. A little charcoal in powder was then added, and the diſtillation being renewed, more fixed air was obtained, which M. Pelletier conſiders as a concluſive proof of the exiſtence of vital air in the calx.

Hence it follows that 100 grains of the very beſt verditer contain, of fixed air 30, of water $3\frac{1}{3}$, of pure lime 7, of oxygene or vital air $9\frac{2}{3}$, and of pure copper 50. The author a ſecond time remarks, that the verditers of inferior quality contain more chalk and leſs copper. It is not directly aſſerted, that the other principles in theſe verditers are unaltered in their proportions. In the above numbers it is obſervable, that more fixed air enters into the compound than is requiſite to convert the lime into chalk. The reſt muſt therefore, in all probability, have united with the calx of copper. Whether the blue colour be owing to its preſence chiefly, is an object deſerving more minute enquiry. It is alſo obſervable, that M. Pelletier's humid analyſis by vitriolic acid, is not alone ſufficient to ſhew that the lime in the common verditers did not poſſeſs the form of ſelenite, inſtead of that of chalk.

The moſt perfect analyſis in the preſent ſtate of chemiſtry, as has already been remarked, under the article Vegetables, can only ſhew the component parts, but not the order of their union. It therefore by no means follows, that the above principles in the ſame preciſe proportions muſt unite and make verditer; but it will be requiſite that a definite calcination of the copper, a certain diviſion, or ſtate either of ſolution or precipitation, or in a word, other circumſtances relative to the order of their union, of which we know ſo little, ſhould take place. M. Pelletier had therefore no inconſiderable part of his taſk remaining to be done, before he could produce the required compound. He was acquainted with the fact, that the refiners prepare the beſt verditer, and that an inferior kind of verditer is made at Paris by precipitating vitriol of copper by vegetable alkali, and converting it to a blue by lime and ſal ammoniac. This verditer becomes greeniſh as it dries. He was likewiſe aware that Berthollet had remarked that the greeniſh precipitate of copper recently made, and ſufficiently diffuſed in water, aſſumes in time, after quick lime has been added, a blue colour, greatly reſembling that of verditer. He made many trials without ſucceſs, ſome of which he relates. They deſerve the notice of chemiſts, but I omit them becauſe leſs immediately connected with the ſubject. He uſed a nitrous ſolution of copper, and precipitated by the alkalis as well mild as pure. A piece of chalk kept for ſome days in this ſolution, aſſumed a very fine green colour, reſembling malachite. The moſt promiſing experiments were thoſe in which lime was the precipitant. It was found that the precipitates were pale green when the proportion of lime was ſmall; but when this proportion was greater than enough to decompoſe the whole of the nitrous ſolution, the precipitates were blue, of more or leſs intenſity. His ſucceſsful proceſs was the following:

Copper was diſſolved without heat in diluted nitrous acid. To this, lime in powder was added with agitation, in ſuch a quantity as to decompoſe nearly the whole of the nitrous ſolution, but not in exceſs, in order that the precipitate might be a pure calx of copper. After ſubſidence, decantation of the nitre of lime, edulcoration with water, and drying upon a cloth, the precipitate was obtained of a pale green colour. A certain quantity of this, with the addition of as much water, if the maſs has been ſuffered to dry, as is ſufficient to convert it into a thin paſte, was put into a large mortar, or upon the grinding-ſtone of the colour-makers. It was then triturated with a ſmall portion of lime in powder. At the inſtant of this addition, the maſs aſſumed a lively blue colour. The quantity of lime made uſe of is from 7 to 10 per cent. of the weight of the precipitate. But this quantity may be aſcertained by trials of a ſmall quantity of the mixture, which may be dried either in the ſun, or in a warm place during the time of triturating. If its colour when dry appears too pale, a ſmall quantity of the precipitate of copper may be added to the maſs, taking care that it ſhall not be enough to make any difference in the livelineſs of the blue. The whole is then to be dried, which is ſpeedily done, and the maſs then proves to be of a colour equal, or even ſuperior to the verditer of England, and poſſeſſing the ſame habitudes when chemically analyſed. The influence of light is of no conſequence in this operation. For the converſion is inſtantaneous, and takes place in the dark.

M. Pelletier is of opinion, that the lime takes the vital air from the calx of copper. I have been diſpoſed to ſuſpect the formation of volatile alkali in this proceſs, which ſtill deſerves to be further examined. He diſtinguiſhes verditer from the cryſtals of azure, becauſe theſe laſt are a combination of copper with fixed air, and from malachite, which may be conſidered as a combination of fixed air with copper ſuperoxygenated.

VESSELS CHEMICAL. See Apparatus.

VINEGAR is an acid produced by a peculiar fermentation from vinous liquors. Its qualities depend much on the method of exciting and of conducting that fermentation. The wine which is generally converted into vinegar, and which for its cheapneſs is generally employed for this purpoſe, is ſuch as has become already ſour; although the better and the more ſpirituous the wine is, and alſo the more of the vinous ſpirit that can be retained in the vinegar, the better and ſtronger this will be. Becher ſays in his Phyſica Subterranea, that having digeſted wine in order to convert it into vinegar in a bottle hermetically ſealed, he found, that although a longer than the ordinary time was required, the vinegar produced was much ſtronger than when free air is admitted. M. Cartheuſer alſo affirms, that the ſtrength of vinegar may be much increaſed by adding ſome ardent ſpirit to the wine before it is expoſed to the acetous fermentation.

Different methods are practiſed by manufacturers for making vinegar, who are generally believed to be poſſeſſed of ſome ſecret for that purpoſe. Nevertheleſs, no more ſeems requiſite in the preparation of good vinegar, than to employ good wine, and to conduct the fermentation in the moſt advantageous method; in the ſame manner as good wine can only be made from good muſt, and by a well conducted fermentation. The principal part of theſe operations is performed by nature.

The method of making vinegar conſiſts in mixing the wine to be fermented with its dregs and its tartar, and in expoſing this liquor to a heat of about ſeventy or eighty degrees. This fermentation ſeems to require more heat than the ſpirituous. It alſo excites more heat and tumult; and although it ought to be allowed to proceed briſkly, yet it is neceſſary from time to time to check it.

Boerhaave deſcribes, in his Elements of Chemiſtry, the following proceſs, which ſeems to be well contrived for the making of vinegar.

Take two large oaken vats or hogſheads, and in each of theſe place a wooden grate or hurdle at the diſtance of a foot from the bottom. Set the veſſel upright, and on the grate place a moderately cloſe layer of green twigs, or freſh cuttings of the vine. Then fill up the veſſel with the footſtalks of grapes, commonly called the cape, to the top of the veſſel, which muſt be left quite open.

Having thus prepared the two veſſels, pour into them the wine to be converted into vinegar, ſo as to fill one of them quite up, and the other but half full. Leave them thus for twenty-four hours, and then fill up the half-filled veſſel with liquor from that which is quite full, and which will now in its turn only be left half-full. Four-and-twenty hours afterwards repeat the ſame operation, and thus go on, keeping the veſſels alternately full and half-full during every twenty-four hours till the vinegar be made. On the ſecond or third day there will ariſe in the half-filled veſſel, a fermentative motion, accompanied with a ſenſible heat, which will gradually increaſe from day to day. On the contrary, the fermenting motion is almoſt imperceptible in the full veſſel; and as the two veſſels are alternately full and half-full, the fermentation is by that means in ſome meaſure interrupted, and is only renewed every other day in each veſſel.

When this motion appears to have entirely ceaſed, even in the half-filled veſſel, it is a ſign that the fermentation is finiſhed, and therefore the vinegar is then to be put into caſks cloſe ſtopped, and kept in a cool place.

A greater or leſs degree of warmth accelerates or checks this, as well as the ſpirituous fermentation. In France it is finiſhed in about fifteen days, during the ſummer; but if the heat of the air be very great, and exceed the twenty-fifth degree of Reaumur's thermometer, the half-filled veſſel muſt be filled up every twelve hours, becauſe if the fermentation be not ſo checked in that time, it will become violent, and the liquor will be ſo heated that many of the ſpirituous parts, on which the ſtrength of the vinegar depends, will be diſſipated, ſo that nothing will remain after the fermentation but a vapid liquor, ſour indeed, but effete. The better to prevent the diſſipation of the ſpirituous parts, it is a proper and uſual precaution to cloſe the mouth of the half-filled veſſel in which the liquor ferments, with a cover made of oak wood. As to the full veſſel, it is always left open, that the air may act freely on the liquor it contains; for it is not liable to the ſame inconveniencies, becauſe it ferments but very ſlowly.

In the Dictionnaire Portatif des Arts et Metiers, another method is deſcribed, by which a very good vinegar is commonly made at Paris, from the lees of wine. For this purpoſe all the wine contained in the lees is preſſed out and put into large caſks, the bung-holes of which are left open. Theſe caſks are put into a hot place, and if the fermentation proceeds too faſt, it muſt be checked by adding more freſh wine. The proceſs is very ſimilar to the foregoing.

The appearances which accompany the acetous fermentation, reſemble much thoſe that occur in the ſpirituous fermentation. In both fermentations, an inteſtine motion, a ſwelling, a hiſſing noiſe, and an ebullition may be perceived. There are, nevertheleſs, eſſential differences between them. Beſides that the products of the vinous and acetous fermentations differ exceedingly, the heat produced by the former is ſcarcely ſenſible, while that produced by the latter is conſiderable. Again there is reaſon to believe, that the vapour which exhales from vinegar during fermentation is not noxious, as the vapour of fermenting wine is; at leaſt, it has not been obſerved to produce ſuch bad effects. On the contrary, as the acid of vinegar more and more diſengages or unfolds itſelf, it ſeems to acquire more power to retain the baſis of fixed air, which is the truly dangerous part of the vapours of fermentation. Laſtly, vinegar does not depoſit tartar as wine does, even although it has been made with wine that had not depoſited its tartar. But the ſediment of vinegar is a viſcid, oily, and very putreſcent matter. The grape-ſtalks uſed in the making of vinegar, to promote and increaſe the fermentation, are covered over with this matter during the operation. They are generally waſhed clean, and carefully preſerved to promote the fermentation of more vinegar, becauſe the acid with which they are ſoaked, acts powerfully as a leaven or ferment. The caſks alſo which have been uſed for the preparation of vinegar are to be cleanſed from the abovementioned viſcid matter, and kept for the ſame uſe, as they are rendered fitter than new caſks for the preparation of vinegar.

It appears that the ſtrength of vinegar is impaired by too ſpeedy fermentation in veſſels not at all ſtopped, moſt probably from the eſcape of ardent ſpirit, which certainly contributes to its formation. Hence ſmall caſks or veſſels imperfectly cloſed, are beſt ſuited to this proceſs. In England the vinegar makers uſe ſeveral hundreds of caſks diſpoſed in the open air, with the bung-hole upwards, and covered each with a tile to exclude the rain. Beer is brewed of a proper ſtrength from malt for this expreſs purpoſe. The addition of hops is not here uſed.

Milk alſo affords vinegar by fermentation. This fluid does not afford ardent ſpirit enough to favour the operation, which therefore requires either the addition of a ſmall portion of ſpirit, or a conſiderable heat, ſuch as that of a warm oven for two or three days.

Much ingenious reaſoning has been offered by philoſophers on the effects of the acetous fermentation, and the component parts of vinegar. The leading and eſtabliſhed facts are, that ardent ſpirit appears neceſſary for the production of this acid by fermentation, and that vital air is abſorbed in the proceſs. Hence it appears to follow that ardent ſpirit contains the acidifiable baſis of vinegar. From the order of convertibility of vegetable acids into each other, it is rendered highly probable, that theſe have one common baſis, and differ only in the greater or leſs degree of acidification. The moſt perfect and laſt ſtate of vegetable acidification is fixed air. Lavoiſier has offered proof that charcoal conſiſts almoſt totally of the baſis of fixed air.

Glaſs veſſels are preferable for the diſtillation of vinegar, as well as for moſt other chemical operations, where their ſize and the required heat will permit. Earthen or ſtone ware veſſels may alſo be uſed. For larger quantities a copper alembic with a glaſs head and worm pipe of pure tin is recommended. Some direct that the inſide ſhould be tinned, and others that it ſhould be ſmeared with greaſe. This laſt contrivance does not ſeem to promiſe much advantage, and may vitiate the acid, ſince Rozier remarks, that fat oils and vinegar have ſome action on each other in diſtillation. There is probably nothing to fear from the bare copper, if the vinegar be poured in hot. For the confectioners have long ſince remarked, that hot vinegar does not corrode or receive any impregnation from their copper veſſels, though there is much danger in ſuffering it to remain in them cold. This has been explained, not from the difference of temperature, but the excluſion of the external air by the vapours of the hot fluid, which in neither caſe can act on the copper, unleſs vital air be preſent to be abſorbed. Diſtilled vinegar is called the acetous acid.

Dr. Crell, in the Journal de Phyſique for October 1785, has given a ſet of experiments to ſhew that all the vegetable acids are convertible into one, and that the primitive acid is contained in the pureſt ſpirit of wine. His reaſoning and inductions are conformable to the theory of phlogiſton. Moſt chemiſts at preſent, whatever may be the theories they maintain, would find it neceſſary to attend ſtrictly to the agency of vital air in proceſſes of this nature. I give the experiments in the words of the Engliſh tranſlation at the end of Scheele's Eſſays. Theſe may be compared with the facts adduced under the article Vegetables.

1. If the reſiduum of dulcified ſpirit of nitre be boiled with a large quantity of nitrous acid, care being at the ſame time taken to condenſe the vapours by a proper apparatus; and if the liquid which has paſſed over be ſaturated with vegetable alkali, nitre and terra foliata tartari will be obtained. If the latter be ſeparated by means of ſpirit of wine, the vinegar may be got by the ordinary proceſs.

2. Upon boiling the reſiduum over again with nitrous acid, the ſame products are obtained. The oftener this proceſs is repeated, the leſs is procured of acid of ſugar, and at length no veſtige of it is to be found.

3. If pure acid of ſugar, completely formed, be boiled with twelve or fourteen times its quantity of nitrous acid, the former diſappears, and the receiver is found to contain phlogiſticated nitrous acid, vinegar, aerial acid, phlogiſticated air, and in the retort there remains a little calcareous earth.

4. If the acid of ſugar be boiled with ſix times its quantity of vitriolic acid, there are found in the receiver vinegar, phlogiſticated vitriolic acid, aerial acid, and in the receiver pure vitriolic acid.

5. By ſaturating the reſiduum of dulcified ſpirit of nitre with chalk, there is formed an inſoluble ſalt, which on being treated with vitriolic acid, yields a real acid of tartar; for, with vegetable alkali, it conſtitutes cream of tartar.

6. If the liquor, from which the tartariſed lime (tartareous ſelenite) was procured, be evaporated, there will remain a dark-coloured matter, which yields, on diſtillation, empyreumatic acid of tartar, and a ſpongy coal. Hence it appears, that ſpirit of wine conſiſts of acid of tartar, of water, and phlogiſton: ſo that it is a native dulcified acid; and nitrous acid, on being mixed with it in moderate quantity, diſlodges the acid of tartar. If more nitrous acid be added, the acid of tartar is converted into acid of ſugar and phlogiſton; and by adding a new portion of nitrous acid, the acid of ſugar is changed into vinegar.

7. If one part of acid of ſugar, together with one and one-half part of manganeſe, be boiled with a ſufficient quantity of nitrous acid, the manganeſe will be almoſt entirely diſſolved, and vinegar, with phlogiſticated nitrous acid, paſs over into the receiver.

8. If acid of tartar and manganeſe be boiled with vitriolic acid, the manganeſe will be diſſolved, and vinegar, with vitriolic acid, be obtained.

9. When acid of tartar, manganeſe and nitrous acid, are boiled together, the manganeſe is diſſolved, and vinegar, together with phlogiſticated nitrous acid, is obtained.

10. If acid of tartar and ſpirit of wine be digeſted together for ſeveral months,

the whole is converted into vinegar, and the air in the veſſel becomes partly fixed, and partly phlogiſticated air.

11. If ſpirit of wine be boiled with vitriolic acid and manganeſe, it will be converted into vinegar and phlogiſticated air.

12. Spirit of wine, by being diſtilled upwards of twenty times from off cauſtic alkali, was changed into vinegar, and a conſiderable quantity of water was obtained.

Hence it follows, according to Crell, that the acids of tartar, and of ſugar, and vinegar, are modifications of the ſame acid, as it contains more or leſs phlogiſton, or as the modern chemiſts would ſay, leſs or more acidified by vital air. The acid of tartar has the greateſt quantity of the phlogiſton; the acid of ſugar a little leſs, and vinegar has the ſmalleſt quantity. Or if the real principle, vital air, be conſidered, its quantities in theſe are in the inverted order, more inſtead of leſs. In theſe experiments, it is neceſſary to employ nitrous acid and fixed alkali, without any admixture of marine acid, otherwiſe the obſerver will be led into miſtakes.

Vinegar, as an acid, unites with all the alkalis, ſome earths, and moſt of the metals; and with theſe baſes it forms compounds, ſome of which are cryſtallizable, and others have not yet been reduced to a regularity of figure.

The affinity * of the acetous acid to theſe ſubſtances, is inferior to that of moſt of the other acids, even of the vegetable and animal kingdoms, as appears from Bergman's table of affinities. The acetous ſalts are eaſily decompoſed by other ſtronger acids, eſpecially by the vitriolic, nitrous, and marine; and at the ſame time the acetous acid may be procured by diſtillation. Theſe ſalts may likewiſe be decompoſed merely by heat; but in this proceſs the acetous acid is alſo decompoſed, and changed chiefly into fixed and inflammable air, in all thoſe inſtances where the acid is ſo ſtrongly combined with the baſis of the ſalt, as to require a certain conſiderable degree of heat to effect its ſeparation.

With ponderous earth the ſaline maſs formed by the acetous acid, does not cryſtallize; but when evaporated to dryneſs, it deliqueſces by expoſure to air. This maſs is not decompoſed by acid of arſenic. Bergman, Nov. Act. Upſ. ii. 223. Although this earth is placed by Bergman at the head of the column of the acetous acid in his table, as having the greateſt affinity, he acknowledges that this ſuperiority is not founded on experiment.

With fixed vegetable alkali this acid unites and forms a deliqueſcent ſalt ſcarcely cryſtallizable, called improperly foliated earth of tartar, and regenerated tartar.

With mineral alkali it forms a cryſtallizable ſalt, which does not deliqueſce. To this ſalt no name has been generally given, but it may not improperly be called acetous ſalt of mineral alkali.

The ſalt formed by uniting vinegar with volatile alkali, called by the various names of ſpirit of Mindererus, liquid ſal ammoniac, acetous ſal ammoniac, and by Bergman, alkali volatile acetatum, is generally in a liquid ſtate, and is commonly believed not to be cryſtallizable, as in diſtillation it paſſes entirely over into the receiver. It nevertheleſs may be reduced into the form of ſmall needle-ſhaped cryſtals, when this liquor is evaporated to the conſiſtence of a ſyrup.

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* Theſe affinities and compounds are from Keir's Dict. *Acid acetous.*

Weſtendorf, by adding his concentrated vinegar to mild volatile alkali, obtained a pellucid liquid which did not cryſtallize, and which by diſtillation was totally expelled from the retort, leaving only a white ſpot. In the receiver under the clear fluid a tranſparent ſaline maſs appeared, which being ſeparated from the fluid, and expoſed to gentle warmth, melted, and threw out abundance of white vapours, and in a few minutes ſhot into ſharp cryſtals reſembling thoſe of nitre. Theſe cryſtals remained unchanged while cold, but, when melted by a gentle warmth, they ſmoked and evaporated. Their taſte at firſt was ſharp and then ſweet, and they poſſeſſed the general properties of neutral ſalts.

The ſalt formed by diſſolving chalk or other calcareous earth in diſtilled vinegar, called ſalt of chalk, or fixed vegetable ſal ammoniac, and by Bergman calx acetata, has a ſharp bitter taſte, appears in the form of cryſtals reſembling ſomewhat ears of corn, which remain dry when expoſed to air, unleſs the acid has been ſuperabundant, in which caſe they deliqueſce. By diſtilling without addition, the acid is ſeparated from the earth, and appears in the form of a white acid and inflammable vapour, which ſmells like acetous ether, ſomewhat empyreumatic, and which condenſes into a reddiſh brown liquor.

This liquor being rectified, is very volatile and inflammable: upon adding water it acquires a milky appearance, and drops of oil ſeem to ſwim upon the ſurface. After the rectification, a reddiſh brown liquor remains behind in the retort, together with a black thick oil. When this earthy ſalt is mixed with a ſolution of Glauber's ſalt, the calcareous earth is precipitated along with the vitriolic acid, the acetous acid uniting with the mineral alkali, makes a cryſtallizable ſalt, or foliated earth, by the calcination of which to whiteneſs, the mineral alkali may be obtained. This acetous calcareous ſalt is not ſoluble in ſpirit of wine.

With magneſia, the acetous acid unites, and, after a perfect ſaturation, forms a viſcid ſaline maſs, like a ſolution of gum arabic, which does not ſhoot into cryſtals, but remains deliqueſcent, has a taſte ſweetiſh at firſt, and afterwards bitter, and is ſoluble in ſpirit of wine. The acid of this ſaline maſs may be ſeparated by diſtillation without addition. See Margraaf's Chemical Works, vol. ii. Wenzel on Affinities, and Bergman on Magneſia.

The earth of alum obtained by boiling alum with alkali, and edulcorated by digeſting in an alkaline lixivium, is diſſolved by diſtilled vinegar in a very inconſiderable quantity. (Wenzel, p. 202.) A conſiderable quantity of the earth of alum, precipitated by alkali, and edulcorated by hot water in Margraaf's manner, (Chemical Works, vol. i. p. 200.) is ſoluble in vinegar, and a whitiſh ſaline maſs is then obtained, which is not cryſtallizable. From this maſs a concentrated acetous acid may be obtained by diſtillation. Margraaf ſays that he obtained ſmall needle-ſhaped cryſtals from a ſolution of earth of alum in acetous acid.

The acetous acid has no action upon ſiliceous earth, for the needle-ſhaped cryſtals obſerved by Durande (Elemens de Chymie, Dijon, iii. 13.) in a mixture of vinegar with the earth precipitated from a liquor of flints, do not prove the ſolubility of ſiliceous earth, as Leonhardi obſerves.

Zinc is ſoluble not only in its metallic and calciform ſtates, but alſo when mixed with other metals, according to the experiments of Meſſrs. Macquer and Montigni. (Gazette de Santé, 1777.) Concentrated vinegar diſſolves zinc with much heat, ſulphureous ſmell, and exhalation of inflammable vapour, and forms with it a congealed maſs, which being diluted with water, yields oblong ſharp cryſtals, by the firſt cryſtallization, and ſtar-like cryſtals afterwards. Wenzel ſays, he obtained foliated talky cryſtals, and Monnet got from this ſolution, tranſparent, friable, talky cryſtals of a white pearly colour, when bruiſed, ſome of a laminated, and others of a granulated form. He obſerved that this ſalt, when thrown on the coals, fulminated at firſt a little, and gave a blueiſh flame, and then melted, letting its acid eſcape, while a yellow calx remained. (Elem. de Chym. iii. 38.)

The acetous ſalt of zinc is decompoſed by diſtillation, without addition, according to Hellot, into water, an inflammable liquor, an oil which at firſt appears yellow, and afterwards green, and white flowers, which burn with a blue flame. Weſtendorf obtained in this diſtillation no oil, but ſome acetous acid; a ſweet-taſted empyreumatic liquor containing zinc; a ſublimate of flowers which were ſweet, ſoluble in water, and burnt with a green flame; and when a ſtronger heat was applied, the zinc ſublimed in its metallic ſtate, leaving a ſpongy coal at the bottom of the retort. The ſolution of zinc in acetous acid gives a green colour to ſyrup of violets, throws down a white precipitate on adding alkalis, or an infuſion of galls, is not precipitated by common ſalt, vitriolated tartar, vitriolic or marine acids, blue vitriol, or corroſive ſublimate, but forms a red precipitate when added to a ſolution of gold; a white precipitate with ſolution of ſilver, a cryſtalline pearly precipitate with ſolution of mercury, and cryſtalline precipitates with ſolutions of biſmuth and of tin. (Weſtendorf, ſ. 45.) Bergman ſays, this acetous ſolution of zinc is decompoſed by the acid of arſenic. (Nov. Act. Upſ. tom. ii.)

Vinegar diſſolves iron with a ſlight effervеſcence, cauſed by the diſengagement of an inflammable gas, and acquires a reddiſh brown colour. The ſolution when evaporated depoſits much ochre, and yields when cold a few deliqueſcent cryſtals, according to Monnet. (Diſſolut. des Metaux.) Theſe cryſtals have a ſweetiſh, ſtyptic taſte: when expoſed to diſtillation their acid eſcapes, and a yellow calx remains which is attractable by the magnet. But Mr. Gellert ſays, that the ſolution yielded by diſtillation only a watry fluid.

Vinegar has ſcarcely any action upon manganeſe, even in a boiling heat. Nevertheleſs concentrated vinegar by being repeatedly diſtilled with manganeſe, becomes ſaturated, and the ſalt is deliqueſcent. (Scheele on Manganeſe.)

Regulus of cobalt is not ſoluble in vinegar, but its calx gives a pale roſe-coloured ſolution, which has the property of being a ſympathetic ink, that receives a green colour from marine acid. This ſolution is not decompoſed by acid of arſenic. (Bergman, Nov. Act. Upſ. ii. 245.)

Vinegar diſſolves nickel, and the ſolution yields green cryſtals. (Bergm. de Nicolo, ſ. 14.)

The eaſy ſolution of lead by vinegar, and the ſalt called ſugar of lead thence reſulting, are well known.

Tin communicates to vinegar, by means of digeſtion, a turbid appearance, and a metallic taſte. Alkalis precipitate a little from this ſolution. (Margraaf's Chem. Works, vol. ii.) This tin does not adhere ſtrongly to the acid, and yields no cryſtals by evaporation, but a yellow gummy ſaline maſs, of an unpleaſant ſmell, which does not deliqueſce, but melts eaſily upon coals, ſwells like borax, and leaves behind a gray ſpongy aſh. This ſolution of tin in vinegar may be decompoſed by iron, zinc, and lead, likewiſe by vitriolic acid, by common ſalt, and by alkalis. It forms a black precipitate, when added to a ſolution of ſilver, and to a ſolution of gold a purple precipitate. (Weſtendorf, ſ. 35.) The precipitate of tin is not more copiouſly ſoluble than metallic tin in concentrated vinegar. (Wenzel, Verw. p. 199.) The calx of tin, which has been ſtrongly calcined either by deflagration with double its quantity of ſaltpetre, and well edulcorated, or the precipitate from a ſolution in tin, by means of ſpirit of ſal ammoniac, are ſo ſoluble in this acid, that cryſtals may be thence obtained, which are white, hard, ſolid, tranſparent, and ſweetiſh, called Mynſicht's ſalt of Jove, or ſalt of tin. This acetous ſalt of tin may be decompoſed by vitriolic acid, by common ſalt, or by alkali. (Bergman in Scheffer's Chem. Works, p. 237.)

Biſmuth and alſo its calx, according to Pott, (Obſerv. Chem. vol. i. p. 167.) are ſoluble in acetous acid, with which they form a bitter acrid liquor, which cannot eaſily be brought to cryſtallize. Wenzel alſo mentions the ſolubility of biſmuth in this acid, (Verw. p. 204.) and ſays that upon evaporating the ſolution a yellow maſs is left, which is no longer ſoluble in water. He ſays that biſmuth is more ſoluble in its metallic than calciform ſtate. However, that its calx is alſo in ſome degree ſoluble in the acetous acid, appears from Bergman. (Nov. Act. Upſ. tom. ii. p. 242.)

Weſtendorf's concentrated vinegar ſeemed to have but little action on biſmuth, for 1½ ounce of the acid, with a digeſtion of twelve hours, diſſolved only eleven grains. (Loc. citat. ſ. 41.)

The above authorities prove clearly that the authors of the Elemens de Chymie, à Dijon, are miſtaken in their aſſertion of the abſolute unſolubility of biſmuth, or of its precipitate, in acetous acid. (Tom. iii. p. 37.)

The regulus of antimony is ſcarcely acted upon by the acetous acid, even when a boiling heat is applied, according to Wenzel and Monnet. Nevertheleſs it appears to be diſſolved in ſufficient quantity, not only by vinegar, but even by wine, to impart to theſe liquors an emetic quality. But this quantity may be too minute to be diſcovered by weighing. Weſtendorf has alſo obſerved, that the vinegar digeſted on regulus of antimony gives a greeniſh colour to the Pruſſian lixivium, although it does not give any indication of iron to infuſion of galls; and that when this vinegar is abſtracted, an appearance of a ſublimate and a metallic reſiduum ſhew that there had been ſome degree of ſolution. The calx and glaſs of antimony are ſomewhat more ſoluble in this acid. The powder precipitated from a ſolution of regulus of antimony in aqua regis, by means of fixed alkali, is ſoluble in concentrated vinegar, but the ſolution on evaporation is not cryſtallizable according to Wenzel. This ſolution may be decompoſed by acid of arſenic. (Bergman, Nov. Act. Upſ. ii. 246.)

The regulus of arſenic is not ſoluble in this acid, but its calx may be diſſolved either in common or diſtilled vinegar. Cadet (Sçavans Etrang. iii.) obtained a ſmoking liquor by diſtilling a mixture of white arſenic and foliated earth. The authors of the Elemens de Chymie, à Dijon, iii. 39. repeated and extended this enquiry, and met with ſome curious reſults, of which Keir gives a tranſlation. The ſubſtance is as follows:

1. Five ounces of diſtilled vinegar were digeſted on a ſand bath, upon white pulverized arſenic. The filtered liquor was covered during evaporation with a white ſaline cruſt, in quantity two gros eight grains. From ſome trials on animals it was much leſs noxious than arſenic itſelf. 2. To a ſolution of this cruſt in water a ſolution of alkali was added, (I ſuppoſe veg. alk.) a ſalt in irregular cryſtals was formed in the courſe of ſome days, which threw down a yellow precipitate from the nitrous ſolution of ſilver. 3. A mixture of equal parts of

foliated earth and white arſenic afforded at firſt a ſmall quantity of clear fluid, in which acid predominated. And the ſecond product ſeparately received was a reddiſh brown liquor of an abominable ſmell, which filled the receiver with fumes. Towards the end of the operation, a black powder ſublimed to the neck of the retort, together with a little reguline arſenic, and a ſubſtance which took fire like ſulphur upon the application of a lighted candle. 4. The red liquor preſerved its property of ſmoking when cold, and emitted the ſame deteſtable ſmell. It gave ſlight indications of acidity.

Theſe chemiſts were deſirous of examining a yellowiſh matter of an oily appearance, which had ſubſided to the bottom of the bottle. For this purpoſe they carefully decanted the ſupernatant liquor, and poured the remainder upon a filter of paper, when before many drops had paſſed, there aroſe a thick ſmoke, forming a column from the veſſel to the ceiling. A ſlight ebullition of the matter was perceived at the ſides of the veſſel, and a beautiful roſe-coloured flame appeared during ſome inſtants. The paper of the filter was burnt at one ſide, and moſt of it was only blackened. After the flame was extinguiſhed, a fat reddiſh matter was obſerved, which being melted on burning coals, gave a white flame, was conſiderably diſtended, and afterwards ſunk, leaving a black ſpot on the coal, which required the utmoſt heat to be effaced. The liquor had been diſtilled three weeks, and the bottle had often been opened when theſe obſervations were made. The inflammability could not proceed from the concentration of the vinegar, for the roſe-colour of the flame, the precipitation of the ſublimate, and the fixity of the ſpot on the coal, prove that theſe two ſubſtances were united, and in a ſtate of combination, which is further evinced by the loſs of the inflammable property, when the liquor was decompoſed by a fixed alkali. This ſmell ſo penetrating and fetid, which exhaled from this new phoſphorus, affected the operators with no other inconvenience, than an unpleaſant ſenſation in the throat, which further confirms the above conjecture, that vinegar corrects arſenic.

The ſaline brown maſs that remained in the retort, was partly ſoluble in hot water, and yielded by evaporation a ſalt which was not deliqueſcent, and afforded no perceptible ſmell of arſenic when placed on burning coals. The reſiduum after this treatment was mealy, white and fixed; the following day it deliqueſced; whence theſe chemiſts concluded that it conſiſted chiefly of alkali which had been enabled to cryſtallize by receiving fixed air from the vinegar.

Vinegar does not act upon mercury in its metallic ſtate, but it diſſolves the metallic calces, as precipitate per ſe, turbith mineral, and the precipitate formed by adding fixed alkali to a ſolution of mercury in nitrous acid; with all which preparations of mercury it forms white, ſhining, ſcaly cryſtals, like thoſe of ſedative ſalt of borax.

Concentrated acetous acid does not diſſolve ſilver in its metallic ſtate, but it readily diſſolves the yellow calces of ſilver precipitated from its ſolution in nitrous acid by means of fuſible ſalt of urine, or volatile alkali; and very copiouſly with the help of a boiling heat, the precipitate thence obtained by means of fixed vegetable alkali. (Margraaf's Chemical Works, i. treatiſe 5th.) The laſt mentioned ſolution yields ſhining, oblong, needle-ſhaped cryſtals, which are changed to a calx by means of ſeveral acids, eſpecially by the marine; and zinc, iron, tin, copper, and quickſilver throw down the ſilver in its metallic form. (Bergman, Anmerk. zu Scheffer, &c. Weſtendorf, lib. cit. & Wenzel, Verwandſchaft.)

The acetous acid makes no impreſſion upon gold in its metallic ſtate. The crude or undiſtilled vinegar decompoſes a ſolution of gold, and produces a dark violet-coloured, and alſo a metallic precipitate. Diſtilled vinegar throws down the gold in its proper ſtate. The precipitate effected by adding fixed alkali, when digeſted with acetous acid, is of a purple colour (Berg. Nov. Act. Upſal. ii. 237.) Weſtendorf's concentrated vinegar diſſolves not only this precipitate, but alſo fulminating gold, and the latter very eaſily. The ſolution, which is yellow, gives with a volatile alkali a yellow precipitate; with a lixivium of blood, a blue precipitate; and both theſe precipitates fulminate. The dry ſalt of gold diſſolves in this acid, and gives oblong yellow cryſtals. (Weſtendorf. Diſp. cit. ſect. 12—15.)

Platina is unſoluble in the acetous acid, but the precipitate obtained by adding fixed alkali to the ſolution is ſoluble in this acid. (Bergm. Nov. Act. Upſal. ii. 238.)

Concerning the action of vinegar on ſpirit of wine, ſee Ether. This acid has no effect upon fat oils, except that when diſtilled together, ſome kind of mixture takes place, as the Abbé Rozier obſerves. (De la Fermentation des Vins, p. iii.) Neither does diſtilled vinegar act upon eſſential oils; but Weſtendorf's concentrated acid diſſolved about a ſixth part of oil of roſemary, or one half its weight of camphor; which latter ſolution was inflammable; and the camphor was precipitated from it by adding water.

Vinegar diſſolves the true gums, and partly the gum reſins, by means of digeſtion. (Poerner, Delin. Pharm. ſect. 85.)

Boerhaave obſerves, that vinegar by long boiling diſſolves the fleſh, cartilages, bones and ligaments of animals. (Elem. Chem. ii. proc. 52.)

The Count de Lauraguais obtained highly concentrated vinegar from verdigriſe in an icy form. This form has hitherto been entirely aſcribed to the cupreous particles combined with, or at leaſt acting upon it; but Mr. Lowitz* has ſhewn, that the acetous acid itſelf poſſeſſes the property of aſſuming a cryſtallized form.

This chemiſt prepared a concentrated vinegar (alkohol aceti) by congelation, in the following manner:—He froze a whole barrel of vinegar as much as poſſible, then diſtilled the remaining unfrozen vinegar in a water bath; by which means he at firſt eſpecially collected the ſpirituous ethereal part; the vinegar which next comes over he froze again as much as poſſible, and afterwards purified it, by diſtilling it again with three or four pounds of charcoal powder. By this means he never failed to procure a very pure, ſweet-ſmelling, highly concentrated vinegar; the agreeable odour of which, however, may be ſtill farther improved by the addition of a proper quantity of the ethereal liquor collected at the beginning of the firſt diſtillation, but which muſt be previouſly dephlegmated by two or three rectifications.

After the diſtillation on the water-bath was over, that no vinegar might be loſt, he removed the retort, with the charcoal powder which remained in it, to a ſand-bath; and thus he obtained, by means of a ſtrong fire, a few ounces more of a remarkably concentrated vinegar, which was of a yellow colour.

Having collected about ten ounces of this concentrated vinegar, he expoſed it to a cold equal to 195 of De L'iſle's thermometer; in which ſituation it ſhot into cryſtals from every part. He let what remained fluid drop away from the cryſtals into a baſon placed underneath, firſt in the cold air, and afterwards at the window within doors. There remained in the bottle ſnow-white finely foliated cryſtals, cloſely accumulated upon each other, which at firſt he took to be nothing but ice: on placing them upon the warm ſtove, they diſſolved into a fluid which was perfectly as limpid as water, had an uncommonly ſtrong, highly pungent, and almoſt ſuffocating acetous ſmell, and in the temperature of 145 of De Liſle's ſcale, immediately congealed into a ſolid white cryſtallized maſs, reſembling camphor.

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* Crell's Chemical Journal, Engliſh, ii. iii.

The quantity of this excellent glacial vinegar amounted to two ounces; and the following are the moſt remarkable properties which it exhibits in this uncommonly beautiful cryſtallized ſtate:

1. In a temperature of 145 degrees, the previouſly liquefied glacial vinegar begins to ſhoot into beautiful arboreſcent and plumous figures, exactly in the ſame manner as water that undergoes a gradual congelation. There is at this time a conſiderable extrication of air-bubbles, and at length the vinegar congeals into a cryſtallized and completely ſolid maſs.

2. This cryſtallized glacial vinegar requires a temperature of at leaſt 126, in order to become fluid again.

3. The cryſtallization of the fluid glacial vinegar is ſooneſt effected by placing it in water mixed with ſnow or ice.

4. If only a part of the cryſtallized glacial vinegar is melted, by the application of the warm hand, an appearance of very fine cryſtallizations is afforded, provided the warmth of the room is not greater than 130 degrees. This may be repeatedly produced. If it is ſuffered to remain undiſturbed in this temperature, large ſpecular cryſtals are ſeen to ſhoot up along the ſides of the bottle, conſiderably above the fluid, and frequently to bend over to the oppoſite ſide, in the form of an arch, till they dip into the liquid vinegar again.

5. One of the moſt remarkable phenomena is this, that, by expoſing to an increaſing cold, a great variety of exceſſively delicate vegetations, reſembling a ſublimation, take place in the empty part of the bottle. Although they ſtretch out very far, and hang as it were floating in the empty part of the bottle, they only adhere by a very ſmall point. They are ſo extremely thin and tranſparent, as not to be diſcernible in certain directions; and they frequently exhibit all the various colours of the rainbow.

6. By placing the melted glacial vinegar in ſnow, the four following equally pleaſing appearances may be produced:

If, as exactly as poſſible, the ſmalleſt degree of cold in which the glacial vinegar is capable of beginning to freeze, be applied, there are immediately formed, on opening the bottle and ſhaking it a little, an immenſe number of extremely thin floating cryſtals, which are in the form of equilateral triangles, quadrangular planes, &c. and exhibit, eſpecially in clear weather, the fineſt variety of colours.

On increaſing the cold, and afterwards opening and ſhaking the bottle as before, beautiful, ſhining, thin cryſtals of a quadrangular, pentangular, hexangular, radiated form, fall to the bottom, and exactly reſemble flakes of ſnow.

In a ſtill greater degree of cold, little radiated balls, or globular lumps, fall down to the bottom, increaſing very quickly in ſize during their deſcent.

Laſtly, if the refrigeration is carried to its higheſt pitch, and the bottle is opened and ſhaken before the cryſtallization has ſpontaneouſly begun, the vinegar

negar congeals throughout, with an extraordinary quickneſs, into a compact, ſnow-white, ſtriated maſs.

For the production of theſe appearances, it is neceſſary that the glacial vinegar be previouſly brought into a perfectly liquid ſtate.

7. The internal ſurface of the bottle, in which the glacial vinegar is kept, is frequently covered over with the fineſt delineated figures, ſome of which are criſped, after the manner of the froſt on windows; others, on the contrary, are of an angular, jagged, or rectilinear form, amongſt which are alſo ſometimes to be ſeen, quite diſtinct from the other figures, equilateral triangles.

8. When the glacial vinegar begins to cryſtallize in a quiet place, the ſurface of the ſtill fluid vinegar is covered over, as ſoon as ſome ſpicular and arboreſcent cryſtals ſhoot from the bottom upwards, with a cruſt as ſhining and ſmooth as a mirror; underneath which, however, a large concavity is immediately afterwards formed by the air, which is extricated in great abundance, and mounts upwards.

9. Glacial vinegar in its ſolid or cryſtallized ſtate, notwithſtanding the great quantity of air-bubbles that are entangled in its whole maſs, occupies much leſs ſpace than it did in its fluid ſtate.

After Mr. Lowitz had attended to theſe ſtriking properties, and had obſerved that vinegar in this ſtate is of ſuch an extraordinary ſtrength and purity as to be in its higheſt degree of perfection, he took all poſſible pains to find out a method of obtaining all the acetous acid in the ſtate of glacial vinegar.

The ſtrength of each ſort of vinegar, which it was neceſſary for him to know in his experiments, by degrees he aſcertained in the following manner: viz. To one drachm of vinegar he added, drop by drop, a clear ſolution of equal parts of ſalt of tartar and water, till all at once a cloudineſs or precipitation appears. Although, on the appearance of this ſign, the acid is already ſuper-ſaturated with the alkali, yet it ſeems to be a more accurate teſt for aſcertaining its ſtrength than the ceſſation of effervеſcence; for as the point of ſaturation approaches, the effervеſcence becomes ſo imperceptible, that it is almoſt impoſſible to determine with preciſion when it is really at an end. Every five drops of the alkaline ſolution, which he finds it neceſſary to add to the vinegar, till the precipitation takes place, he reckons as one degree. Thus, for example, if a determinate quantity of vinegar requires 25 drops for that effect, he denotes its ſtrength by five degrees. This is about the ſtrength of good diſtilled vinegar.

That vinegar which in conſequence of its concentration is capable of cryſtallizing in a great degree of cold, he calls cryſtallizable vinegar; the cryſtals of vinegar ſeparated after the cryſtallization is completed, from the remaining fluid portion, he calls glacial vinegar; and laſtly, to the fluid reſiduum he gives the name of mother ley of vinegar.

From a great number of experiments he found, that vinegar muſt have at leaſt twenty-four degrees of concentration, before it can be brought to cryſtallize by expoſure to the moſt intenſe cold. Vinegar muſt be of the ſtrength of 42 degrees at leaſt, in order to become glacial vinegar; viz. in this ſtate of concentration it has the property of cryſtallizing in a degree of cold not exceeding that in which water begins to freeze.

He found that charcoal, on being diſtilled with vinegar in a water-bath, poſſeſſes the ſingular, and hitherto unknown property, of imbibing a certain quantity of the acetous acid in a very concentrated ſtate, and of retaining it ſo ſtrongly, that the acid cannot be ſeparated from it again, but by the application of a conſiderably greater degree of heat than that of boiling water. Upon this circumſtance is founded the new method which he diſcovered of concentrating vinegar, ſo as to obtain all its acid in the pureſt ſtate, viz. that of a glacial vinegar.

Let a barrel of vinegar be concentrated by freezing in the manner before deſcribed, and let the concentrated vinegar thus obtained, free from all inflammable or ſpirituous parts, be put into two retorts: add to each of them five pounds of good charcoal reduced to a fine powder, and ſubject them to diſtillation in a water-bath. When no more drops of vinegar come over, put the diſtilled liquor into two freſh retorts; and after adding five pounds of charcoal powder to each, proceed, as before, to diſtillation in a water-bath. In the mean time, the two firſt retorts are to be placed in a ſand-bath, that, by means of a briſk fire, the cryſtallizable vinegar which is retained in the apparently dry charcoal powder may be expelled from it. The heat muſt be ſtrong enough to make the drops follow one another every two ſeconds; and when, in this degree of heat, 20 ſeconds intervene between each drop, the vinegar which has been collected muſt be removed; for what follows is hardly any thing elſe but mere water. In this manner about ſix ounces and a half of cryſtallizable vinegar, which is generally of the ſtrength of between 36 and 40 degrees, may be collected from each retort. As ſoon as the diſtillation by the water bath in the two other retorts is over, the diſtilled liquor is to be poured back again into the firſt retorts upon the charcoal powder, which remains in them, and which has been already uſed; and from each of theſe retorts the remaining cryſtallizable vinegar (which generally amounts to as much as the firſt quantity) is to be abſtracted by diſtillation in a ſand-bath. Theſe operations may be alternately repeated, till all the acid of the vinegar which had been concentrated by freezing, is converted into cryſtallizable vinegar; or until the diſtilled liquor, conſtantly becoming weaker and weaker at every repetition of the diſtillation, comes over at length in the ſtate of mere water; which, with the abovementioned quantity of charcoal powder, generally happens at the fourth or fifth diſtillation. Now, in order to obtain the greateſt part of the pure acid contained in the cryſtallizable vinegar, in the form of glacial vinegar, it muſt be ſet to cryſtallize in a great degree of cold; and the mother ley muſt be afterwards thoroughly drained from the glacial vinegar, by letting it drop from the cryſtals, firſt in the cold, and then in the room before the window. The mother ley may be rendered further cryſtallizable, by diſtilling it with a little charcoal powder; the weaker part which comes over firſt being put aſide. But if a perſon wiſhes to keep the cryſtallizable vinegar (which far exceeds Mr. Weſtendorf's in point of ſtrength) for other purpoſes, and without ſeparating any glacial vinegar from it, he muſt diſtil the whole of it again with charcoal powder in a ſand-bath.

Mr. Lowitz found by accurate experiments, that by means of this curious proceſs ten pounds of vinegar concentrated by freezing to the nineteenth degree, may be made to yield 38 ounces of cryſtallizable vinegar, from which 20 ounces of glacial vinegar may be obtained.

What conſtitutes the excellence of this method, is, that the concentration and purification are effected by one and the ſame medium; viz. the charcoal powder; in conſequence of which, both intentions are fulfilled at the ſame time.

The cryſtallization of the vinegar is, at the ſame time, the means by which it acquires its higheſt degree of concentration, and its greateſt purity; for all the extraneous matter, which cannot otherwiſe be parted, even with the aſſiſtance of the charcoal, from the genuine acid, is thus ſeparated from the pure acetous cryſtals, and left behind in the mother ley.

It was this extraneous matter, which cannot well be ſeparated from the pure acetous acid by any other means but by cryſtallization, that led Dr. Amburger, agreeably to the reſults of his experiments, to draw concluſions contrary to Mr. Weſtrumb's theory, reſpecting the convertibility of the acetous acid into the acid of ſugar.

Mr. Lowitz, in the courſe of his experiments relative to this proceſs, for concentrating and purifying vinegar by charcoal powder and cryſtallization, made the following obſervations:

1. With one pound of charcoal powder very little more than ten drams of cryſtallizable vinegar are obtained; and this is the caſe, whether the vinegar, which is to be diſtilled over it, be ſtrong or weak, in a large or in a ſmall quantity. It is taken for granted, however, that the vinegar ſhall contain at leaſt as much acid as the charcoal powder is capable of imbibing and retaining in the diſtillation by the water-bath.

2. The quantity of cryſtallizable vinegar which is obtained, is in a direct ratio to the quantity of charcoal powder employed.

3. The leaſt cold in which cryſtallizable vinegar, prepared by means of charcoal powder, ſhoots into cryſtals, is that of 173 degrees.

4. In the firſt diſtillation a yellow cryſtallizable vinegar comes over; but in the ſubſequent diſtillations, by which the vinegar is purified from all its colouring or inflammable matter, it is always obtained perfectly limpid like water.

5. Cryſtallizable vinegar of the ſtrength of 38 degrees, yielded glacial vinegar of 54 degrees of concentration, whilſt the ſtrength of the mother-ley amounted only to 28 degrees.

6. All glacial vinegar is not of an equal ſtrength.

7. Mr. Lowitz thinks he has obſerved that glacial vinegar is ſtronger, in proportion to the intenſeneſs of the cold by which it has been produced.

8. In a cold of 183 degrees, he obtained glacial vinegar of the ſtrength of 54°, which he finds to be the higheſt degree of concentration which the acetous acid is capable of obtaining.

9. As the water-bath, though it inſures ſucceſs, is often inconvenient, and takes up a great deal of time, it may be diſpenſed with by a ſkilful management of the fire; which, however, requires very great attention.

Mr. Lowitz, in the further proſecution of the experiments with concentrated glacial vinegar, obſerved many other curious phenomena, which are as follow:

If vinegar concentrated by freezing be diſtilled very ſlowly, and without any addition, there comes over, at laſt, a ſmall quantity of cryſtallizable vinegar, from which, by means of a great degree of cold, a little glacial vinegar may be procured. This method, however, is not only very tedious, but the vinegar thus obtained is highly phlogiſticated and empyreumatic.

By abſtracting a large quantity of common diſtilled vinegar, over charcoal powder, firſt in a water-bath and afterwards in a ſand-bath, cryſtallizable vinegar

gar may in like manner be obtained; but, on account of the great proportion of water in diſtilled vinegar, this method is extremely tedious.

Reflecting on this property of glacial vinegar, viz. that it requires for its liquefaction a degree of warmth conſiderably greater than that in which the completely liquefied glacial vinegar is capable of cryſtallizing, Mr. Lowitz was led to diſcover a method by which cryſtallizable vinegar may be made to cryſtallize in a cold 15 degrees leſs than that which was before required, viz. Into ſome previouſly liquefied glacial vinegar he dipped a thin cotton wick, cryſtallized the vinegar by placing it in ſnow, and then in a cold of 158 degrees applied the ſame wick, with the cryſtals adhering to it, to the ſurface of ſome cryſtallizable vinegar of the ſtrength of 38 degrees; there immediately formed round the end of the wick a number of needle-ſhaped cryſtals, which viſibly increaſed in ſize; the ſurface of the vinegar became covered over with an icy cruſt; a great number of radiated cryſtals, exactly reſembling flakes of ſnow, gradually ſunk to the bottom of the bottle, where they continued to accumulate, and at length the vinegar, throughout, ſhot into fine large cryſtals. By this mode of treatment, it is rendered unneceſſary to wait for a cold of 173 degrees, ſo that we have it in our power, at all times, to obtain vinegar in the ſtate of very beautiful tranſparent cryſtals, of a regular priſmatic ſhape, and ſeveral inches in length.

From two pounds three ounces of perfectly dry ſoda acetata, and a pound and a half of highly concentrated oil of vitriol, Mr. Lowitz prepared, according to Mr. Weſtendorf's method, 13 ounces of an alcohol aceti, of the ſtrength of 32 degrees. By expoſing it in the night time to a cold of 174 degrees, and by applying to its ſurface ſome cryſtals of glacial vinegar, adhering to a cotton-wick, he immediately brought it to cryſtallize; and the next morning, in a cold of 182 degrees, he found it formed into beautiful priſmatic cryſtals, which were three inches in length. After the mother ley was poured off, theſe cryſtals weighed three ounces two drams and a half. He diſtilled this mother ley, the ſtrength of which ſtill amounted to 24 degrees, with two pounds of charcoal powder, in a water-bath: the vinegar which came over into the receiver had a very ſweet ſmell, and was now only of the ſtrength of 16 degrees. From the reſiduous powder he afterwards obtained, by diſtillation in a ſand-bath, two ounces ſix drams and a half of a ſmoking cryſtallizable vinegar, of the ſtrength of 36 degrees.

The properties of this glacial vinegar, prepared from Mr. Weſtendorf's vinegar, are preciſely the ſame as thoſe of the glacial vinegar which is obtained by means of charcoal powder alone; whence it follows, that the vinegar is not altered by its combination with a foreign body (viz. the alkali), and its ſubſequent ſeparation from it; or that the charcoal produces the ſame effect as the alkali.

After much reflection, Mr. Lowitz was ſo happy as to find out another very effectual method of ſeparating the acetous acid from the other ſubſtances combined with it, ſo as to obtain it at once in the ſtate of a glacial vinegar of the greateſt poſſible ſtrength. The ſeparating medium which he thought of, is a vitriolated tartar ſuper-ſaturated with vitriolic acid, a ſalt, in which, conformably to his purpoſe, the vitriolic acid exiſts in a perfectly dry and dephlegmated ſtate.

His firſt buſineſs was to contrive an eaſy method of preparing this ſalt, whoſe properties have been hitherto but little examined; after various trials, he hit upon the following ſucceſsful proceſs:

Mix together in a tall matraſs ſeven parts of water with an equal quantity of oil of vitriol, and to the very hot mixture add, as quickly as the effervefcence will permit, four parts of ſalt of tartar, or levigated pot-aſhes. As ſoon as the mixture becomes cool, the ſuperſaturated vitriolated tartar ſhoots into fine large cryſtals. After the whole is become quite cold, and the cryſtallization is at an end, the liquor (which may ſerve again for a freſh mixture of the ſame kind) is to be poured off, and the ſalt which remains in the matraſs is to be ſhaken together, and to be well rinſed as quickly as poſſible with cold water, in order to cleanſe it from all the vitriolic acid which adheres to its ſurfaces, and which would otherwiſe be prejudicial to the dry acid. The cryſtals are afterwards to be dried by expoſure to the fire, and to be triturated to a very fine powder, which, juſt before it is uſed, muſt be again thoroughly exſiccated.

By means of this ſalt, a highly concentrated glacial vinegar may be obtained in the following manner:

Let three parts of acetated ſoda, prepared with vinegar diſtilled over charcoal, and evaporated to perfect dryneſs, be melted in a ſtrong heat; then pour it out, and rub it to a very fine powder. Mix this powder very accurately with eight parts of ſuperſaturated vitriolated tartar, that has been previouſly well dried, and in like manner reduced to a fine powder; put the whole into a retort, and diſtil it with a gentle heat, in ſuch a manner, that, along with the drops ſome vapours alſo may be perceived to come out of the neck of the retort; but by no means ſo that the receiver ſhall be filled with theſe vapours. Notwithſtanding the moderate heat, the vinegar comes over very faſt; and the quantity of glacial vinegar, of the ſtrength of 54 degrees, which is thus obtained, amounts to nearly two parts, and poſſeſſes all the characters which have been before deſcribed.

By this proceſs, ſeven pounds of glacial vinegar may be obtained from 300 pounds of common vinegar; and from five pounds of diſtilled vinegar, of the ſtrength of five degrees, two ounces of glacial vinegar may be procured in the ſpace of ſix hours.

This glacial vinegar generally acquires an unpleaſant ſmell, from which, however, it may be completely freed by diſtillation with charcoal powder, in the proportion of at leaſt five or ſix parts of the latter to one part of the vinegar; or, to three ounces of this vinegar add about a dram of perfectly dry and finely pulverized acetated calcareous earth; ſhake them well and repeatedly together, and let the mixture remain expoſed to the ſun-ſhine till the diſagreeable ſmell is entirely gone; then re-diſtil the vinegar in a gentle heat.

In its purification, whatever be the way in which it is effected, this glacial vinegar is unavoidably lowered ſome degrees in ſtrength.

The melting of the acetated ſoda only ſerves for the expulſion of all the watery parts from the ſalt; but a glacial vinegar of the ſtrength of between 46 and 50 degrees may be procured from a merely exſiccated ſoda acetata.

For the production of glacial vinegar, by means of the ſuperſaturated vitriolated tartar, not only the acetated mineral alkali, but alſo well dried acetated calcareous earth may be employed.

How much preferable this laſt proceſs, with vitriolated tartar ſaturated with an exceſs of acid, is to the other, in which glacial vinegar is prepared from Mr. Weſtendorf's vinegar, will appear from a comparative ſtatement of the following particulars:

1. In the direct ſeparation by means of oil of vitriol, we are reſtrained from adding to the acetated ſalt as much of the vitriolic acid as is neceſſary for the expulſion

pulſion of all the vinegar contained in the acetated ſoda, leſt the required acetous acid ſhould be too much debaſed by vitriolic or ſulphureous acid: whereas, in the ſeparation by means of the ſuperſaturated vitriolated tartar, no harm at all can ariſe from adding an exceſs of the vitriolated ſalt, for the purpoſe of diſlodging the whole of the vinegar contained in the acetated ſalt; for the ſuperfluous portion of vitriolic acid, combined with the alkali, adheres to it too ſtrongly, and is too fixed in the fire, to be diſengaged, and raiſed up by that gentle degree of heat which is ſufficient for the ſeparation of the acetous acid.

2. In the affuſion of a very concentrated oil of vitriol upon the thoroughly dried acetated ſalt, we are far from being able to make the vitriolic acid penetrate the ſalt in an equal manner, which, however, is a matter of great conſequence: whereas, in the trituration of the acetated ſalt with the ſuperſaturated vitriolated tartar of Mr. Lowitz, the moſt equal commixture of both ſalts is readily effected.

3. During the affuſion (though it be performed with the greateſt caution) of highly concentrated oil of vitriol, a great heat is excited, whereby ſome of the vinegar is inſtantly conſumed, a volatile ſulphureous acid is produced, and part of the acetous acid is diſſipated and loſt in the form of vapour. But nothing of this kind takes place in Mr. Lowitz's laſt invented method: for there the ſalts do not begin to act reciprocally upon each other till the fire is applied.

4. The vinegar prepared according to Mr. Weſtendorf's method, always contains an admixture of vitriolic acid; which, however, for the reaſon already aſſigned, is by no means the caſe with the glacial vinegar of Mr. Lowitz, provided the management of the fire is properly attended to.

5. Twenty-four ounces of acetated ſoda, treated with oil of vitriol, give only 12 ounces of a barely cryſtallizable vinegar, of the ſtrength of 32 degrees, from which, at moſt, only ſix ounces of glacial vinegar can be procured. On the other hand, the ſame quantity of acetated ſoda (previouſly fuſed) treated with the ſuperſaturated vitriolated tartar, yields nearly 16 ounces of glacial vinegar, of the ſtrength of 54 degrees.

6. Glacial vinegar cannot be obtained from Mr. Weſtendorf's vinegar, except in winter, and by expoſure to a very intenſe cold: but in the laſt deſcribed method of Mr. Lowitz, an exceedingly ſtrong glacial vinegar may be immediately prepared at any time.

7. The ſuperſaturated vitriolated tartar may be prepared from various pharmaceutical reſidua; for inſtance, from the vitriolated tartar which remains after the purification of pot-aſhes, and the reſiduum from the liquor anodynus; and even the reſiduum, after the preparation of glacial vinegar by means of ſuperſaturated vitriolated tartar, may, when the Glauber's ſalt which is produced is ſeparated from it, be made to ſerve again, on the addition of freſh oil of vitriol, for another ſimilar proceſs.

A weak glacial vinegar may be concentrated in the following eaſy and at the ſame time entertaining manner:

Place the bottle containing the fluid glacial vinegar, which is to be concentrated, up to its neck in a veſſel full of ice and water: in another quantity of previouſly concentrated glacial vinegar, ſurrounded in like manner with ice, dip a thin cotton-twiſt or wick; as ſoon as ſome cryſtals are perceived to have attached themſelves to the wick, apply the ſame to the ſurface of the glacial vinegar, which is to be concentrated, and it will be ſeen to ſhoot into conſiderably large cryſtals. In the courſe of an hour or two, let the weaker part which ſtill remains fluid, be poured off, into another bottle, from the concentrated and cryſtallized glacial vinegar.

In winter this concentration of the glacial vinegar may be effected in the following ſtill more ſimple manner:

Pour the glacial vinegar, which is to be concentrated, into a glaſs bottle or jar with four ſides; cryſtallize the vinegar by placing it in ſnow, or by expoſure, in any other way, to cold; and then place it in a warm room, before the window (where, however, the rays of the ſun are prevented from entering), in ſuch a manner that one ſide of the bottle may come into cloſe contact with the cold pane of the window. In the courſe of ten or twelve hours, the ſtrongeſt part of the acid will arrange itſelf, in cluſters of cryſtals, all along that ſide of the bottle which touches the pane of the window, whilſt on the other ſide of the bottle which faces the room, the much weaker portion of the vinegar is found in a perfectly fluid ſtate; ſo that all that remains to be done, is to pour off this fluid part into another bottle.

From the weaker portion that is ſeparated in the concentration of the glacial vinegar, more glacial vinegar may yet be obtained, by expoſure to cold, and more eſpecially by means of the before-deſcribed proceſs with the cotton wick: and even the ſtill weaker mother ley, which remains at laſt, may very eaſily be brought to cryſtallize afreſh, by the help of a gentle diſtillation.

Deciſive experiments, and thoſe frequently repeated, convinced Mr. Lowitz, that the 54th degree is the higheſt pitch of concentration to which glacial vinegar is capable of being brought. Notwithſtanding all the pains he took, he never was able either by diſtillation, or by any of the other concentrating methods already mentioned, to puſh the concentration of glacial vinegar even a ſingle degree farther; on the contrary, the vinegar was rendered weaker by ſome degrees in all ſuch attempts.

The reaſon of this ſeems to be, that the acetous acid, like ſome of the mineral acids, when ſtill further dephlegmated, or deprived of its watery parts, is no longer capable of remaining in a condenſed ſtate, but probably aſſumes an aërial or gaſeous form; otherwiſe, in the further abſtraction of its watery parts, how could there be ſuch a conſtant diminution of its ſtrength, evidently owing to a loſs of acid?

Upon this principle we can eaſily account for the extraordinary quantity of air bubbles, which are produced as often as the glacial vinegar paſſes from the fluid to the ſolid cryſtallized ſtate. The white appearance of the cryſtals depends on the ſame cauſe.

Hence, too, we ſee the impoſſibility of having a glacial vinegar, which ſhall retain its ſolid cryſtallized form during ſummer, unleſs it be kept in a place where the warmth never exceeds, at moſt, 126 degrees. Thus, for example, in a cellar whoſe temperature remains conſtantly at 131 degrees, ſummer and winter, a ſtrong glacial vinegar would never become fluid; but if the ſame vinegar ſhould be brought into this cellar in a perfectly liquefied ſtate, it would never cryſtallize there, on account of the difference between the temperature required for the cryſtallization, and that which is neceſſary for the liquefaction of glacial vinegar.

By very accurate experiments Mr. Lowitz found, that the leaſt cold which ſuffices, without the application of ice or ſnow, for the cryſtallization of a perfectly fluid glacial vinegar of the ſtrength of 54 degrees, is that of 132 degrees. All that is needful is, after letting the glacial vinegar ſtand ſome time in water of the above-mentioned temperature, to open the bottle, and ſhake it a little ſo that the external air may enter, and have free acceſs to the vinegar.

Laſtly, we may at all times obtain glacial vinegar in a cryſtallized form, by means of an artificial cold; viz. Pour the vinegar into a thin ſlender bottle, wrap round this ſome rag moiſtened with a little rectified vitriolic æther, and whirl it about briſkly in the air.

It is a circumſtance worthy of notice, that the weakeſt glacial vinegar, in reſpect to the quantity of alkali neceſſary to its ſaturation, is ſtronger than the ſtrongeſt ſmoking ſpirit of nitre. On this teſt however ſee Attraction, p. 164.

VIRGULA DIVINATORIA. See Rod, Divining.

VITAL AIR. See Air, Vital.

VITRIFICATION. See Glass, alſo Silex.

VITRIOL. The ſaline combination of copper with the vitriolic acid is called blue vitriol, in commerce. Vitriolic acid and iron form green vitriol, or the green copperas of the ſhops. Vitriol of zinc is called white copperas. The looſeneſs and inaccuracy of theſe denominations are evident. Some chemiſts have endeavoured to generalize the term vitriol, by applying it to all combinations containing vitriolic acid. Thus they would ſay, vitriol of iron, or of copper, or of lime; but this method has never been generally adopted. It is uſual however to call all the metallic ſalts vitriols, which contain vitriolic acid. See Acid, Vitriolic; Sulphur; Pyrites, and the ſeveral Metals.

VITRIOLIC ACID. See Acid, Vitriolic.

VOLATILE ALKALI. See Alkali, Volatile.

VOLATILITY. That property of bodies by which they are diſpoſed to aſſume the vaporous or elaſtic ſtate, and quit the veſſels in which they are placed. In many inſtances of chemical operation, the moſt ſimple ſubſtances are found to be the moſt volatile, and many principles are rendered more fixed by combination. This is the moſt general obſervation; but there are a number of inſtances in which volatility follows from combination, though for the moſt part leſs in degree than was poſſeſſed before by the more volatile of the matters ſo combined. Of all ſubſtances known the earths are the leaſt volatile, next to theſe are ſome of the metals, and theſe are followed by the fixed alkalis and a few of the acids. All other bodies poſſeſs conſiderable volatility.

VOLCANOS *. The combuſtion of thoſe enormous maſſes of bitumen which are depoſited in the bowels of the earth, produces volcanos. They owe their origin more eſpecially to the ſtrata of pyritous coal. The decompoſition or action of water upon the pyrites determines the heat, and the production of a great quantity of inflammable air, which exerts itſelf againſt the ſurrounding obſtacles, and at length breaks them. This effect appears to be the chief cauſe of earthquakes; but when the concourſe of air facilitates the combuſtion of the bitumen and the inflammable air, the flame is ſeen to iſſue out of the chimneys or vents which are made: and this occaſions the fire of volcanos.

There are many volcanos ſtill in an active ſtate on our globe, independent of thoſe of Italy, which are the moſt known. The Abbé Chappe has deſcribed three burning in Siberia. Anderſon and Von Troil have deſcribed thoſe of Iceland. Aſia and Africa contain ſeveral: and we find the remains of theſe fires or volcanic products in all parts of the globe.

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* Chaptal, Elem. ii. 221.

Naturaliſts inform us that all the ſouthern iſlands have been volcanized; and they are ſeen daily to be formed by the action of theſe ſubterraneous fires. The black colour of the ſtones, their ſpungy texture, the other products of fire, and the identity of theſe ſubſtances with thoſe of the volcanos at preſent burning, are all in favour of the opinion that their origin was the ſame.

When the decompoſition of the pyrites is advanced, and the vapours and elaſtic fluids can no longer be contained in the bowels of the earth, the ground is ſhaken, and exhibits the phenomena of earthquakes. Mephitic vapours are multiplied on the ſurface of the ground, and dreadful hollow noiſes are heard. In Iceland, the rivers and ſprings are ſwallowed up; a thick ſmoke mixed with ſparks and lightning is then diſengaged from the crater; and naturaliſts have obſerved that, when the ſmoke of Veſuvius takes the form of a pine, the eruption is near at hand.

To theſe preludes, which ſhew the internal agitation to be great, and that obſtacles oppoſe the iſſue of the volcanic matters, ſucceeds an eruption of ſtones and other products, which the lava drives before it; and laſtly, appears a river of lava, which flows out, and ſpreads itſelf down the ſide of the mountain. At this period the calm is reſtored in the bowels of the earth, and the eruption continues without earthquakes. The violent efforts of the included matter ſometimes cauſe the ſides of the mountain to open; and this is the cauſe which has ſucceſſively formed the ſmaller mountains which ſurround volcanos. Montenuevo, which is a hundred and eighty feet high, and three thouſand in breadth, was formed in a night.

This criſis is ſometimes ſucceeded by an eruption of aſhes which darken the air. Theſe aſhes are the laſt reſult of the alteration of the coals; and the matter which is firſt thrown out is that which the heat has half vitrified. In the year 1767, the aſhes of Veſuvius were carried twenty leagues out to ſea, and the ſtreets of Naples were covered with them. The report of Dion, concerning the eruption of Veſuvius in the reign of Titus, wherein the aſhes were carried into Africa, Egypt, and Syria, ſeems to be fabulous. Mr. de Sauſſure obſerves that the ſoil of Rome is of this character, and that the famous catacombs are all made in the volcanic aſhes.

It muſt be admitted, however, that the force with which all theſe products are thrown is aſtoniſhing. In the year 1769, a ſtone twelve feet high and four in circumference, was thrown to the diſtance of a quarter of a mile from the crater: and in the year 1771, Sir William Hamilton obſerved ſtones of an enormous ſize, which employed eleven ſeconds in falling. This indicates an elevation of near two thouſand feet.

The eruption of volcanos is frequently aqueous: the water, which is confined, and favours the decompoſition of the pyrites, is ſometimes ſtrongly thrown out. Sea ſalt is found among the ejected matter, and likewiſe ſal ammoniac. In the year 1630, a torrent of boiling water, mixed with lava, deſtroyed Portici and Torre del Greco. Hamilton ſaw boiling water ejected. The ſprings of boiling water in Iceland, and all the hot ſprings which abound at the ſurface of the globe, owe their heat only to the decompoſition of pyrites.

Some eruptions are of a muddy ſubſtance; and theſe form the tufa, and the puzzolano. The eruption which buried Herculaneum is of this kind. Hamilton found an antique head, whoſe impreſſion was well enough preſerved to anſwer the purpoſe of a mould. Herculaneum at the leaſt depth is ſeventy feet under the ſurface of the ground, and often at one hundred and twenty.

The puzzolano is of various colours. It is uſually reddiſh; ſometimes grey, white, or green: it frequently conſiſts of pumice ſtone in powder; but ſometimes it is formed of calcined clay. One hundred parts of red puzzolano afforded Bergman, ſilex 55, alumine 20, lime 5, iron 20.

When the lava is once thrown out of the crater, it rolls in large rivers down the ſide of the mountain to a certain diſtance, which forms the currents of lava, the volcanic cauſeways, &c. The ſurface of the lava cools, and forms a ſolid cruſt, under which the liquid lava flows. After the eruption, this cruſt ſometimes remains, and forms hollow galleries, which Meſſrs. Hamilton and Ferber have viſited: it is in theſe hollow places that the ſal ammoniac, the marine ſalt, and other ſubſtances, ſublime. A lava may be turned out of its courſe by oppoſing banks or dykes againſt it: this was done in 1669, to ſave Catania; and Sir William Hamilton propoſed it to the king of Naples to preſerve Portici.

The currents of lava ſometimes remain ſeveral years in cooling. Sir William Hamilton obſerved, in 1769, that the lava which flowed in 1766 was ſtill ſmoking in ſome places.

When the current of lava is received by water, its cooling is quicker; and the maſs of lava ſhrinks ſo as to become divided into thoſe columns which are called baſaltes. The famous Giant's Cauſeway is the moſt aſtoniſhing effect of this kind which we are acquainted with. It exhibits thirty thouſand columns in front, and is two leagues in length along the ſea coaſt. Theſe columns are between fifteen and ſixteen inches in diameter, and from twenty-five to thirty feet long.

The baſaltes are divided into columns of four, five, ſix, and ſeven ſides. The emperor Veſpaſian made an entire ſtatue, with ſixteen children, out of a ſingle column of baſaltes, which he dedicated to the Nile, in the Temple of Peace.

Baſaltes afforded Bergman, per quintal, ſilex 56, alumine 15, lime 4, iron 25.

Lava is ſometimes ſwelled up and porous. The lighteſt is called pumice-ſtone.

The ſubſtances thrown out by volcanos are not altered by fire. They eject native ſubſtances, ſuch as quartz, cryſtals of amethyſt, agate, gypſum, amianthus, felt-ſpar, mica, ſhells, ſchorl, &c.

The fire of volcanos is ſeldom ſtrong enough to vitrify the matters it throws out. We know only of the yellowiſh capillary and flexible glaſs thrown out by the volcanos of the iſland of Bourbon, on the 14th of May 1766 (M. Commerſon), and the lapis gallinaceus ejected by Hecla. Mr. Egolfrigouſon, who is employed by the obſervatory at Copenhagen, has ſettled in Iceland, where he uſes a mirror of a teleſcope which he has made out of the black agate of Iceland.

The ſlow operation of time decompoſes lavas, and their remains are very proper for vegetation. The fertile iſland of Sicily has been every where volcanized. Chaptal obſerved ſeveral ancient volcanos at preſent cultivated; and the line which ſeparates the other earths from the volcanic earth, conſtitutes the limit of vegetation. The ground over the ruins of Pompeia is highly cultivated. Sir William Hamilton conſiders ſubterranean fires as the great vehicle uſed by nature, to extract virgin earth out of the bowels of the globe, and repair the exhauſted ſurface.

The decompoſition of lava is very ſlow. Strata of vegetable earth, and pure lava, are occaſionally found applied one over the other; which denote eruptions made at diſtances of time very remote from each other, ſince it requires nearly two thouſand years before lava receives the plough. An argument has been drawn from this phenomenon to prove the antiquity of the globe: but the ſilence of the moſt ancient authors concerning the volcanos of the kingdom of France, of which we find ſuch frequent traces, proves that theſe volcanos have been extinguiſhed from time immemorial; a circumſtance which carries their exiſtence to a very diſtant period. Beſides this, ſeveral thouſand years of connected obſervations have not afforded any remarkable change in Veſuvius or Etna; nevertheleſs theſe enormous mountains are all volcanized, and conſequently formed of ſtrata applied one upon the other. The prodigy becomes much more ſtriking, when we obſerve that all the ſurrounding country, to very great diſtances, has been thrown out of the bowels of the earth.

The height of Veſuvius above the level of the ſea, is three thouſand ſix hundred and fifty-nine feet; its circumference, thirty-four thouſand four hundred and forty-four. The height of Etna is ten thouſand and thirty-ſix feet; and its circumference one hundred and eighty thouſand.

The various volcanic products are applicable to ſeveral uſes.

1. The puzzolano is of admirable uſe for building in the water: when mixed with lime it ſpeedily fixes itſelf; and water does not ſoften it, for it becomes continually harder and harder. Chaptal has proved that calcined ochres afford the ſame advantage for this purpoſe; they are made into balls, and baked in a potter's furnace in the uſual manner. The experiments made at Sette, by the commiſſary of the province, prove that they may be ſubſtituted with the greateſt advantage inſtead of the puzzolano of Italy.

2. Lava is likewiſe ſuſceptible of vitrification; and in this ſtate it may be blown into opake bottles of the greateſt lightneſs, which Chaptal ſays he has done at Erepian and at Alais. The very hard lava, mixed in equal parts with wood-aſhes and ſoda, produced, ſays he, an excellent green glaſs. The bottles made of it were only half the weight of common bottles, and much ſtronger; as was proved by Chaptal's experiments, and thoſe which Mr. Joly de Fleury ordered to be made under his adminiſtration.

3. Pumice-ſtone likewiſe has its uſes; it is more eſpecially uſed to poliſh moſt bodies which are ſomewhat hard. It is employed in the maſs or in powder, according to the intended purpoſe. Sometimes, after levigation, it is mixed with water to render it ſofter.

U

ULTRAMARINE. A blue colour, made from lapis lazuli. The manipulations for making it are variouſly deſcribed by authors, and conſiſt in pulverizing the ſtone very finely, by ignition, quenching it in water, and ſubſequent levigation. This powder is then carefully ſtirred by ſmall portions at a time into a maſs of reſinous compoſition, from which it is again extracted by waſhing and kneading in hot water. Some artiſts uſe the mere powder of lapis lazuli without any ſubſequent management.

I find it difficult to form an opinion as to what happens in this proceſs, which ſeems to be merely of a mechanical nature. Whether it differs at all from ſimple elutriation and ſubſidence, by which the finer parts of powders are ſeparated from their coarſer parts; and if ſo, in what reſpect, are queſtions which demand the teſt of experiment. What may be the uſe of the reſinous compound? Do the parts of the fineſt colour adhere leſs forcibly to the reſin, and are therefore waſhed out firſt? It ſeems hardly probable, more eſpecially if, as Neri * informs us, the ſame proceſs may be applied to blue enamel, by which I ſuppoſe he means glaſs tinged with cobalt.

Kunckel † deſcribes a proceſs which he ſays was ſucceſsful in his hands; and though upon peruſal it ſeems capable of being much ſimplified, I ſhall give it unaltered in this place, becauſe at leaſt as ſimple as any of the other receipts.

Lapis lazuli was reduced to pieces about the ſize of peas, then ignited and extinguiſhed in ſtronger vinegar. The author ſays, diſtilled vinegar is preferable. The ſtone was in the next place triturated with vinegar to an impalpable powder. This is ſaid to be the moſt important part of the operation. Of a compoſition of equal parts very pure virgin wax and colophony, a quantity was taken of the ſame weight as that of the powdered ſtone. This was melted in a glazed earthen plate, and the powder was added by a little at a time, and well ſtirred in. The maſs was then poured into cold water and left for eight days, at the end of which, two veſſels of glaſs were filled with water ſo hot as barely to ſuffer the hand to be plunged in it. A piece of the compoſition was then kneaded under water till it was ſuppoſed that the fineſt part of the colour was extracted. The maſs was then transferred to the other water, and afforded a paler and leſs valuable blue than the firſt. The waters were left at reſt for four days and then decanted off, and the powder carefully collected. The quantity of the beſt blue is very ſmall; but the ſame maſs, by kneading in different waters, eſpecially when the quantity operated upon is large, affords three or four different kinds. Cleanlineſs of the hands, and of all the veſſels and materials made uſe of, is of the utmoſt conſequence in the manufacture.

UMBER. A brown ochreous earth uſed as a pigment. It acquires a reddiſh colour when ſlightly heated, but in a ſtronger heat becomes again brown, and magnetic, and in a ſtill ſtronger is fuſed into a black glaſs. It does not effervеſce with acids before roaſting, but after that proceſs the iron it contains is ſoluble.

Kirwan alſo mentions under this name, in his Argillaceous Genus, a brown or blackiſh ſubſtance which ſtains the fingers, and is very light. This was long ſuppoſed to be a clay; but M. Hupſch, in the Berlin Memoirs for 1777, ſhews that it conſiſts of particles of decayed wood mixed with bitumen.

UNION. This word is often uſed by chemiſts to denote the combination of principles, or rather their co-exiſtence in any compound. Thus it is ſaid that the parts of a mere mixture are united mechanically; but in an actual combination they are ſaid to be chemically united.

URANITE, OR URANIUM. A new metallic ſubſtance diſcovered by the celebrated Klaproth in the mineral called *Pech blende*; which ſee.

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* L'Art de la Verrerie, 239.

† Loc. cit. 240.

URINE. This excrementitious fluid, in its natural ſtate, is tranſparent, of a yellow colour, a peculiar ſmell and ſaline taſte. Its production as to quantity, and in ſome meaſure quality, depends on the ſeaſons and the peculiar conſtitution of the individual. It is obſerved, that perſpiration carries off more or leſs of the fluid, which would elſe have paſſed off by urine; ſo that the profuſion of the former is attended with a diminution of the latter.

From the alkaline ſmell of urine kept for a certain time, and other circumſtances, it was formerly ſuppoſed to be an alkaline fluid; but Berthollet has ſhewn that it contains an exceſs of phoſphoric acid. He found likewiſe that the urine of gouty patients contains a leſs quantity of this exceſs; whence he rationally conjectures that the acid retained in the blood, and conveyed through the ſyſtem, muſt produce irritation, pain, and other bad conſequences.

Many chemiſts have analyſed urine by diſtillation. Much phlegm comes firſt over, which ſpeedily putrefies; and this affords volatile alkali, though it ſhews no ſigns of that principle in its freſh ſtate. At the ſame time a ſubſtance of an earthy appearance falls down from the urine, which conſiſts of phoſphorated lime, with the acid of the ſtone of the bladder. *Salts of urine* are ſeparable by evaporation and cooling, which is the uſual method, as the phlegm is of no value. They conſiſt, for the moſt part, of two ſalts; the one formed of phoſphoric acid and mineral alkali, and the other of the ſame acid with volatile alkali. Beſides theſe ſalts, and the phoſphorated lime which appears to be ſuſpended by virtue of the exceſs of acid, urine contains the common ſalt taken with our food, and a portion of ſuch other ſaline matters as may occaſionally have been taken.

The ſalts obtained by evaporation and cryſtallization from urine, are clogged with a thick mucilaginous matter, of which they may be deprived by ſolutions in water and evaporation. In theſe proceſſes, however, it is obſerved, that the product of cryſtals is greatly diminiſhed if the ſolution, filtration, and cooling, be prepared in open veſſels. A cloſe apparatus of tin may be uſed for this purpoſe. Two ſtrata of ſalt are then obtained, the upper of which has the form of ſquare tables, and is phoſphorated mineral alkali; and beneath this lies another ſalt cryſtallized in regular tetrahedral priſms, which is phoſphorated volatile alkali. Bergman ſeems, in his blow-pipe experiments, to have uſed theſe ſalts under the denomination of microcoſmic ſalt, in the proportion they are obtained together from urine. It is probable that after all the modern diſcoveries relative to PHOSPHORUS, and the Acid of PHOSPHORUS, moſt chemiſts will prefer making them by direct combination of the acid and alkalis reſpectively, or by the proceſs of M. Giobert, inſtead of the leſs eaſy and unpleaſant method here mentioned.

The mucilaginous reſidue, or mother water of urine after the cryſtallization of ſalts, is partly ſoluble in ardent ſpirit. This portion, which appears to poſſeſs the ſaponaceous ſtate, is ſuſceptible of cryſtallization, but is deliqueſcent. By deſtructive diſtillation it affords upwards of half its weight of mild volatile alkali, a little oil, and ſome ſal ammoniac. Its reſidue reddens ſyrup of violets. Scheele has diſcovered that the volatile alkali in this matter is combined with acid of benzoin, which ſeparates when vitriolic or marine acid is added to the aqueous ſolution. Crell's Journal, Engliſh, ii. 19.

Water takes up an extractive matter from the mother water of urine. This is not ſoluble in ardent ſpirit, is eaſily dried, and very little diſpoſed to attract moiſture. Its products by diſtillation are the ſame as thoſe of animal matters in common.

The urine uſually ſpoken of by chemiſts is that which has paſſed the proceſs of digeſtion. The clear urine which paſſes off immediately after meals, is diſtinguiſhed by the name of crude urine, and contains a very ſmall portion either of ſaline or extractive matter. It is thought from various circumſtances, particularly its ſpeedy paſſage, to be tranſmitted by filtration from the ſtomach and inteſtines, through the cellular membranes directly to the bladder.

The ſpontaneous change or putrefaction of urine is attended with diſtinct phenomena, which have been enumerated and deſcribed by Mr. Hallé, in the Memoirs of the Society of Medicine at Paris, for 1779. The colouring matter ſubſides, volatile alkali flies off, and the predominating acid is in ſome inſtances greatly increaſed. The alkaline ſmell is ſucceeded in courſe of time by another much more nauſeous. Various depoſitions are thrown down, and cryſtals ſeparated, which it does not appear from Fourcroy, whoſe Elements I follow in this reference, that M. Hallé examined chemically.

Quicklime and the alkalis decompoſe the ſalts of urine; and the diſengaged volatile alkali flying off in an impure ſtate, inſtantly exhibits a ſtrong unpleaſant ſmell. Volatile alkali added to freſh urine ſaturates the exceſs of acid, and by that means cauſes the phoſphoric ſalt of lime, which was materially ſuſpended by that exceſs, to fall down. Hence, as Berthollet remarks, the quantity of diſengaged acid, or its proportions, may be aſcertained from the weights of the precipitates thrown down.

Acids produce no obvious change in freſh urine; but they ſpeedily deprive putrid urine, or its ſediment, of their ſmell. There is little doubt but they do this by neutralizing the volatile alkali.

Many metallic ſolutions are decompoſed in the way of double affinity by urine; the ſolvent of the metal ſeizing the alkalis of the urinous ſalts, and the phoſphoric acid uniting with the neutral, moſt commonly in an inſoluble compound. See PHOSPHORUS, p. 655; alſo PRECIPITATE, ROSE-COLOURED.

Concerning the acid matter which appears to be the chief component part of the ſtone, or urinary calculus, ſee STONES, or CALCULI, found in the bodies of animals.

W

WADD. This name is given to plumbago or black lead.

WADD BLACK. An ore of manganeſe found in Derbyſhire. It is remarkable for the property of taking fire when mixed with linſeed oil. See p. 597.

WALKLERA. The Swediſh name for a grey ſtone marrow. The word ſignifies Fuller's earth.

WAND. See Rod, Divining.

WASHING. See Elutriation; alſo Tin, p. 940.

WATER. It is ſcarcely neceſſary to give any definition or deſcription of this univerſally known fluid. It is a moſt tranſparent fluid, poſſeſſing a moderate degree of activity with regard to organized ſubſtances, which renders it friendly to animal and vegetable life, for both which it is indeed indiſpenſably neceſſary. Hence it acts but ſlightly on the organs of ſenſe, and is therefore ſaid to have neither taſte nor ſmell. It appears to poſſeſs conſiderable elaſticity, and yields in a perceptible degree to the preſſure of air in the condenſing machine, as Canton proved, by including it in an open glaſs veſſel with a narrow neck. This condenſation is proportioned to the preſſure, and it recovers its original dimenſions when the force is removed. The ſame elaſtic force is ſhewn by the rebounding of ſtones or bullets, which ſtrike the ſurface of water obliquely, as is ſeen in the diverſion of boys, which in this country they call making ducks and drakes. A flat ſtone is thrown from the hand, nearly in an horizontal direction, with its ſurface parallel to that of the water, upon which it paſſes, by repeated bounds, with nearly the ſame facility as if the water were frozen; till at laſt the force of projection being expended, it ſinks. The muſical ſonorouſneſs of water paſſing in certain circumſtances among pebbles, is another proof of its elaſticity, and perhaps the ſlight adheſion of its particles.

Water does not poſſeſs any conſiderable denſity. Moſt mineral ſubſtances are heavier than this fluid, and among organized matters, there are perhaps none, except oils, and the products of art, which if lighter than water do not owe this property to their mechanical ſtructure. At a moderate temperature water aſſumes the ſolid ſtate, or freezes; and at a degree of heat far below that required to fuſe any of the ſimple metals but mercury, its internal parts aſſume the elaſtic ſtate, and fly off with ebullition. The freezing and boiling points of water are aſſumed as the ſtandards for admeaſurements of heat. See Thermometer, alſo Heat. Its weight alſo is uſed as the ſtandard for ſpecific gravities; ſee Gravity, Specific; alſo Spirit, Ardent. Its capacity for heat is taken as the ſtandard of the ſpecific heats of bodies. And in a word, the ſolubility or inſolubility of bodies in this fluid compoſes a large part of the ſcience of chemiſtry.

When water is cooled gradually, it contracts in its dimenſions till within 8° of freezing, and then expands till it begins to aſſume the ſolid ſtate. Congealed water or ice is conſiderably larger in its dimenſions than water, upon which it therefore floats. The expanſion of ice, at the time of its formation, is made with ſuch force as to burſt the ſtrongeſt metallic veſſels. The aſſumption of the ſolid ſtate in water is effected, like other cryſtallizations, under a ſymmetrical figure. The parts which become ſolid firſt by freezing, have the form of daggers croſſing each other at angles of 60 degrees. The cryſtallization of ice is alſo ſeen to advantage in ſnow and hoar froſt, which are of the nature of the vegetation of ſalts, though probably they may not require the co-operation of light.

Steam, or the vapour of water, poſſeſſes a ſtrong power of expanſion, which is greater the higher its temperature. This power has within the laſt century been very advantageouſly applied to mechanical purpoſes. The vapour of water is more expanſible in the ſame weight and temperature than air; whence the ſteam in half-filled veſſels always occupies the upper place, and moiſt air is leſs heavy than dry. Common air imbibed by water, and afterwards expelled again, is found to contain ſomewhat more of vital air than before. It follows therefore, that the vital part of the atmoſphere is more diſpoſed to combine with water than the azotic part. This effect is remarkably perceived in fogs, which commonly exhibit the peculiar ſmell of burned gunpowder or azotic air; and muſt be aſcribed to a proportion of the vital air having combined with the water of the fog.

The eolipile is a copper veſſel, or globe, with a ſmall aperture on one ſide. If this be heated and then immerſed in water, it will be partly filled by the preſſure of the atmoſphere; and if this water be then made to boil, the ſteam will iſſue out with conſiderable violence, and excite a fire in the ſame manner as bellows. This has been thought to indicate a decompoſition of the water; but it is not the ſteam which produces this effect, but the air it carries with it by its mechanical impulſe; for if the nozzle of an eolipile be inſerted directly into the fire, without leaving any ſpace for the interpoſition of a body of air, it will not excite but extinguiſh the fire, as Dr. Lewis proved by experiment.

Water is not only the common meaſure of ſpecific gravities, but the tables of this element (ſee p. 366) may be uſefully employed in the admeaſurement of irregular ſolids; for one cubic foot is very nearly equal to 1000 ounces avoirdupois. The numbers of the table denoting the ſpecific gravities, do therefore denote likewiſe the number of ounces avoirdupois in a cubic foot of each ſubſtance.

Native water is ſeldom, if ever, found perfectly pure. The waters that flow within, or upon the ſurface of the earth, contain various earthy, ſaline, metallic, vegetable, or animal particles, according to the ſubſtances over or through which they paſs. Rain and ſnow waters are much purer than thoſe, although they alſo contain whatever floats in the air, or has been exhaled along with the watery vapours. Margraaf has analyſed by gentle diſtillation ſome clear rain and ſnow waters that he had very carefully collected in glaſs veſſels. The ſeveral reſiduums obtained by diſtilling a hundred meaſures of rain water, each of which contained thirty-ſix ounces, he diſtilled and evaporated, till no more remained than ſix or eight ounces of water, which was very turbid. From this remainder he obtained by filtration, a hundred grains of a yellowiſh white calcareous earth; and the filtrated liquor ſtill contained ſome earthy particles ſuſpended in it. Upon adding ſome drops of a ſolution of ſalt of tartar to this filtrated liquor, he obtained by evaporation a few grains of cryſtals, which had the appearance of nitre and common ſalt. From theſe cryſtals he inferred, that the rain water contained a ſmall portion of nitrous and marine acids; and from the colour of the cryſtals, which was browniſh, he concludes that it alſo contained ſome oil and viſcous particles. He further proved the preſence of marine acid in rain water, by adding a concentrated reſiduum of diſtilled rain to ſolutions of ſilver, mercury, and lead, in nitrous acid; from all which ſolutions precipitates were thereby formed. He diſcovered the earthy, ſaline, mucilaginous, and oily principles, by expoſing rain water to the rays of the ſun, during ſome months, in a glaſs veſſel covered ſo as to exclude the duſt, but not air; by which means the water underwent a kind of fermentation or putrefaction, and a greeniſh ſlime was formed on the ſides and bottom of the containing veſſel. This fermentation he found could not be excited by treating in the ſame manner the rain water that had paſſed over in the diſtillation made in order to procure the above-mentioned reſiduum.

Margraaf having treated a hundred meaſures of ſnow water in the ſame manner as he had done the rain water, obtained ſixty grains of a ſimilar white calcareous earth, together with the ſame ſaline, mucilaginous, and oily principles, but obſerved that the rain water contained a larger proportion of the nitrous acid, and the ſnow water more of the marine acid. Upon a further examination of the calcareous earths obtained from rain and ſnow, he diſcovered that they contained a ferruginous matter.

The purity of water may be known by the following marks or properties of pure water:

1. Pure water is lighter than water that is not pure; for not only the ſubſtances uſually diſſolved in water are heavier than water, but alſo the ſpecific gravity of a ſolution of any of theſe ſubſtances in water is generally greater than the intermediate ſpecific gravity of the water and of that ſubſtance.

2. Pure water is more fluid than water that is not pure; hence it is ſaid to occaſion a louder ſound when poured from one veſſel into another.

3. It has no colour, ſmell, or taſte.

4. It wets more eaſily than the waters containing metallic and earthy ſalts, called hard waters, and feels ſofter when touched.

5. Soap, or a ſolution of ſoap in ſpirit of wine, mixes eaſily and perfectly with it.

6. It is not rendered turbid by adding to it a ſolution of gold in aqua regia, or a ſolution of ſilver, or of lead, or of mercury, in nitrous acid, or a ſolution of ſugar of lead in water.

Boerhaave, Macquer, and other chemiſts, maintain, that pure water is unalterable; and others, as Borichius, Boyle, Wallerius, that it may be decompoſed or reſolved into other principles, eſpecially into earth.

Boyle relates, that one ounce of water, diſtilled carefully in glaſs veſſels two hundred times, yielded ſix drams of a white, light, inſipid earth, fixed in the fire, and indiſſoluble in water. Boerhaave attributed the earth obtained by diſtillation of water, to duſt floating in laboratories. Other chemiſts have made experiments to aſcertain the truth of that of Boyle. Liedenfroſt found, that when pure diſtilled water is diſſipated or evaporated by throwing it into a red hot iron ſpoon, he always obtained a quantity of earth. Wallerius obtained a ſcruple and a half of fine white earth by triturating during two hours a dram of diſtilled water. This earth, he ſays, is ſoluble in acids, is convertible into a hard maſs by a red heat, which maſs is unſoluble by acids, and is vitrifiable into a white tranſparent glaſs by a more violent heat. He found alſo, that a larger quantity of earth is depoſited from boiling water with a ſtrong, than with a gentle fire. See the Swediſh Memoirs for the year 1760. Margraaf has made experiments with his accuſtomed accuracy, from which it appears, that by diſtillation, and alſo by evaporation with the heat of the ſun, of rain water, the purity of which had been previouſly aſcertained by thirteen diſtillations, he obtained a white, light, ſhining earth. This earth could not be vitrified with the heat requiſite for the fuſion of ordinary glaſs; but by a more violent and longer continued fire it was melted into a yellow greyiſh maſs. He found, that about half of this earth was ſoluble in nitrous acid, and that the other half was not fuſible by fire; but that, by addition of half its quantity of ſalt of tartar, it was convertible into a tranſparent glaſs. The part of the earth that was diſſolved in nitrous acid, was afterwards precipitated from that acid by vitriolic acid, with which it formed a ſelenites; and hence Margraaf infers, that it is a true calcareous earth. He does not determine the claſs of earths to which the inſoluble part of the earth thus obtained by diſtilling water ought to be referred. Margraaf obſerves, that earth is more copiouſly depoſited from water boiling with a ſtrong than with a gentle heat. The quantity of earth that he obtained, in one experiment, from ſeventy-two ounces of diſtilled water, by twelve diſtillations, was nine or ten grains.

Lavoiſier however maintains, that the earth thus obtained by diſtilling water proceeds from the veſſels employed ; and the experiments of Scheele appear to have decided that it is ſo. See his Treatiſe on Air and Fire.

Margraaf obtained earth from water by another experiment. He put two ounces of diſtilled water into a glaſs veſſel ten inches high, and from one to two inches in diameter, and cloſed the mouth with a ſmooth glaſs ſtopper. After the water had been agitated up and down in this tube eight days, it was obſerved to be turbid ; and upon continuing the agitation eight days longer, he obſerved diſtinctly, eſpecially upon expoſing the tube to the rays of the ſun, particles of earth floating in the water.

The action of water upon various ſaline ſubſtances, or their reſpective ſolubilities, conſtitutes an object of great value in the ſcience of chemiſtry. This has been occaſionally ſhewn under the reſpective articles. But as theſe reſults may be of value ſeen all together, I ſhall here inſert three tables from the Notes on Macquer's Dictionary.

The following Table ſhews the quantities of the ſaline ſubſtances that could be diſſolved in an ounce of water, with the heat of 50° of Fahrenheit's ſcale, according to experiments made by Mr. Spielman. Inſtit. Chemiæ, p. 48.

	Grains		Grains
Terra foliata Tartari	470	Salt of Seignette	137
Salt of Sedlitz	384	Blue Vitriol	124
Epſom Salt	324	Green Vitriol	80
Salt of Tartar	240	Purified Nitre	60
Vegetable Salt	212	Sal Polychreſt of Glaſer	40
White Vitriol	210	Vitriolated Tartar	30
Sal Gem	200	Sublimate Mercury	30
Salt of Soda	200	Borax	20
Sal Ammoniac	176	Alum	14
Common Salt	170	Volatile Salt of Amber	5
Salt of Glauber	168	Arſenic	5
Salt of Lorraine	168	Crude Tartar	4
Salt of Sylvius	160	Cream of Tartar	3

The following Table is copied from Muſchenbroek. The eight firſt experiments were made by Boerhaave, and the reſt by Muſchenbroek, with a heat of 38°.

Sea Salt	oz. 2	were diſſolved in	oz. 6 and dr. 3 of pure water
Sal Gem	oz. 1		oz. 3 and dr. 2
Sal Ammoniac	oz. 1		oz. 3 and dr. 2
Nitre	dr. 9		oz. 6
Borax	dr. 4		oz. 10
Alum	oz. 1		oz. 14
Epſom Salt	oz. 1		oz. 1 and dr. 2
Green Vitriol	dr. 1½		oz. 3

Arſenic	oz.	1	were diſſolved in	oz.	30
Blue Vitriol	gr.	50		gr.	850
Salt of Hartſhorn	gr.	50		gr.	765
Sugar of Lead	gr.	50		gr.	595
Salt of Tartar	gr.	50		gr.	85
Glaſs Gall	gr.	50		oz.	$7\frac{1}{2}$
Cream of Tartar	gr.	50		oz.	1000 of boiling water

Fifty grains of cream of tartar may be diſſolved in 100 grains of lime water. Hiſt. de l'Acad. Royale, 1732.

Sugar of milk, dr. 7. were diſſolved in lb. 1. of water, heated to the 167°.

According to Neumann's experiments, the quantities of ſalts ſoluble in an ounce of water are expreſſed in the following Table. He does not mention the heat employed. It was probably between 50° and 60°.

White powd. Sugar	oz.	2	Blue Vitriol	dr.	2
Brown powd. Sugar	oz.	2	Pure Nitre	dr.	1 gr. 10
White or brown Sugar Candy	dr.	9	Sal Prunell	dr.	1
Sal Diureticus	oz.	1	Soluble Tartar	dr.	1
Epſom Salt	oz.	1	Alum	ſcr.	$2\frac{1}{2}$
Sedlitz Salt	dr.	6	Sal Polychreſt	ſcr.	2
Pure fixed Alkali	dr.	6	Arcanum Duplicatum	dr.	$\frac{1}{2}$
White Vitriol	oz.	$\frac{1}{2}$	Vitriolated Tartar	dr.	$\frac{1}{2}$
Martial Vitriol	oz.	$\frac{1}{2}$	Sugar of Milk	ſcr.	1
Sal Gem	dr.	3 ſcrup. 1	Sugar of Lead	ſcr.	1
Sea Salt	dr.	3	Emetic Tartar	ſcr.	1
Salt of Glauber	dr.	2	Borax	gr.	15
Sal Ammoniac	dr.	2	Salt of Sorrel	gr.	10
Volatile Sal Ammoniac	dr.	2	White Tartar	gr.	5
Potaſh	dr.	2	Cryſtals of Tartar	gr.	5

Water when ſaturated with one ſalt is capable of diſſolving a conſiderable portion of another ſalt; and when ſaturated with this alſo, it may ſtill diſſolve a third, a fourth, or more ſalts. Thus, according to Neumann, four ounces of water that have been ſaturated with a dram and a few grains of alum, will ſtill diſſolve five drams of nitre, then half an ounce of green vitrol, ſix drams of common ſalt, three drams of ſoluble tartar, and five drams of ſugar. In the ſame manner alſo, four ounces of water ſaturated with half an ounce of nitre, will diſſolve half an ounce of white vitriol, ſix drams of common ſalt, ſix drams of ſal ammoniac, half an ounce of ſoluble tartar; and after all theſe an entire ounce of ſugar.

Mr. Eller has publiſhed an account of the following experiments concerning the ſolutions of different ſalts in the ſame water. See Mem. of the Acad. of Berlin for the year 1750.

In each experiment, he employed eight ounces of diſtilled water. He found that this quantity of water, when ſaturated

With four ounces of nitre, diſſolved one ounce five drams of fixed alkali, and half an ounce of common ſalt.

With three ounces one dram and one ſcruple of common ſalt, diſſolved three drams of nitre, and ſix drams of fixed alkali.

With three ounces and a half of foſſil ſalt, diſſolved half an ounce of nitre.

With half an ounce of cream of tartar, diſſolved half an ounce of Sedlitz ſalt, and half an ounce of fixed alkali.

With an ounce and a half of vitriolated tartar, diſſolved half an ounce of fixed alkali.

With three ounces and a half of Glauber's ſalt, diſſolved two drams of nitre and as much ſugar.

With four ounces of ſoluble tartar, diſſolved half an ounce of pure nitre.

With four ounces of Epſom ſalt, diſſolved half an ounce of fine ſugar.

With two ounces and a half of ſal ammoniac, diſſolved five drams of foſſil ſalt.

With an ounce and a half of volatile ſalt of hartſhorn, diſſolved an ounce of nitre and half an ounce of ſugar.

With four drams and two ſcruples of borax, diſſolved half an ounce of fixed alkali.

With two ounces and a half of alum, diſſolved ſix drams of common ſalt, and one dram of Epſom ſalt.

With nine ounces and a half of green vitriol, diſſolved an ounce and a half of Sedlitz ſalt, two drams of nitre, and three ounces of refined ſugar.

With nine ounces of blue vitriol, diſſolved an ounce of nitre, three drams of common ſalt, and an ounce of ſugar.

With four ounces and a half of white vitriol, diſſolved one ounce of refined ſugar.

Water has long been conſidered as an elementary or ſimple ſubſtance. But the chemiſts of our own time, in their reſearches into the nature of elaſtic fluids, have obtained water in circumſtances where there is the higheſt reaſon to conclude that it is produced by combination; and in other experiments its decompoſition into two principles, namely, vital air and inflammable air, is judged to take place.

The powers of nature, which are ever the ſame, and are continually performing their operations before us, whether we underſtand them or not, often preſent facts of the utmoſt value and importance, which we overlook, or regard with indifference. Hence it happens, that when an enlightened obſerver makes any diſcovery, it is almoſt always obſerved that ſomebody has ſeen the fact before him, or given ſome confuſed hints reſpecting its theory. It is evident however, that the firſt diſcoverer, if there be any merit in diſcovery, is not the man who finds the treaſure, and ſuppoſes it to be none, but he who is conſcious of its value, and applies it to uſe. On theſe principles it is, that the claims of the diſcoverers of the compoſition of water muſt be eſtimated. The facts appear to be as follow:

Previous to the month of October, 1776, the celebrated Macquer, aſſiſted by M. Sigaud de la Fond, made an experiment by burning inflammable air in a bottle, without exploſion, and holding a white china ſaucer over the flame. His intention appears to have been that of aſcertaining whether any fuliginous ſmoke was produced; and he obſerves that the ſaucer remained perfectly clean and white, but was moiſtened with perceptible drops of a clear fluid, reſembling water, and which in fact appeared to him and his aſſiſtant to be nothing but pure water. He does not ſay whether any teſt was applied to aſcertain this purity, neither does he make any remark on the fact *.

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* Dictionnaire de Chymie, 2d edition, Paris, 1778. Art. Gas Inflammable, vol. ii. p. 314, 315.

In the month of September, 1777, Meſſrs. Bucquet and Lavoiſier, not being acquainted with the fact, which is incidentally and conciſely mentioned by Macquer, made an experiment to diſcover what is produced by the combuſtion of inflammable air. They fired five or ſix pints of inflammable air in an open and wide-mouthed bottle, and inſtantly poured two ounces of lime-water through the flame, agitating the bottle during the time the combuſtion laſted. The reſult of this experiment ſhewed that fixed air was not produced[†].

Before the month of April, 1781, Mr. John Warltire, encouraged by Dr. Prieſtley, fired a mixture of common and inflammable air in a cloſe copper veſſel, and found its weight diminiſhed. Dr. Prieſtley likewiſe, before the ſame period, fired a like mixture of inflammable air and dephlogiſticated air in a cloſed glaſs veſſel, Mr. Warltire being preſent. The inſide of the veſſel, though clean and dry before, became dewy, and was lined with a ſooty ſubſtance[‡]. Theſe experiments were afterwards repeated by Mr. Cavendiſh and Dr. Prieſtley, and it was found that the diminution of weight did not take place, neither was the ſooty matter perceived[‖]. Theſe circumſtances therefore muſt have ariſen from ſome imperfection in the apparatus or materials, with which the former experiments were made.

It was in the ſummer of the year 1781, that Mr. Henry Cavendiſh was buſied in examining what becomes of the air loſt by phlogiſtication, or combuſtion, and made thoſe valuable experiments which were read before the Royal Society on the 15th of January, 1784[§]. He burned 500,000 grain meaſures of inflammable, with about $2\frac{1}{2}$ times the quantity of common air, and by cauſing the burned air to paſs through a glaſs tube eight feet in length, 135 grains of pure water was condenſed. He alſo exploded a mixture of 19,500 grain meaſures of dephlogiſticated or vital, and 37,000 of inflammable air in a cloſe veſſel. The condenſed liquor was found to contain a ſmall portion of nitrous acid, when the mixture of the air was ſuch that the burned air was not much phlogiſticated, that is, when the proportion of vital air was conſiderable. This great philoſopher, who may be conſidered as the true diſcoverer of the compoſition of water, appears to think with Mr. Watt, that in thoſe experiments of Dr. Prieſtley, wherein the vitriolic and nitrous acids ſeemed to be converted into vital air, the acids ſerved only to decompoſe the water, by depriving it of its phlogiſtic or combuſtible part; but he thinks it unneceſſary to include the conſideration of elementary heat, as Mr. Watt does, becauſe in his opinion it is more likely that there is no ſuch thing, and that the bringing the conſideration forward in every chemical experiment, in which increaſe or diminution of heat takes place, might occaſion more trouble and perplexity than it is worth[¶].

In the mean time, M. Lavoiſier continued his reſearches, and during the winter of 1781-1782, together with M. Gingembre, he filled a bottle of ſix pints with inflammable air, which being fired, and two ounces of lime-water poured in, was inſtantly ſtopped with a cork, through which a flexible tube communicating with a veſſel of dephlogiſticated or vital air was paſſed. The inflammation ceaſed, except at the orifice of the tube, through which the vital air was preſſed, where a beautiful flame appeared. The combuſtion continued a conſiderable time, during which the lime-water was agitated in the bottle. Neither this, nor the ſame experiment repeated with pure water, and with a weak ſolution of alkali inſtead of lime-water, afforded the information ſought after, for theſe ſubſtances were not at all altered.

[†] Acad. Par. 1781, p. 470.

[‡] Prieſtley, v. 395.

[‖] Phil. Tranſ. lxxiv. 126. Dr. Prieſtley ſuppoſed the ſooty matter to be part of the mercury uſed in filling the veſſel. Phil. Tranſ. lxxiv. 332.

[§] Mr. Lavoiſier relates that Dr. Blagden, Sec. R. S. (who was preſent at the performing of the capital experiment of burning inflammable and dephlogiſticated air in a cloſed veſſel on the 24th June, 1783) informed him that Mr. Cavendiſh had already done the ſame thing, and obtained water. See the Memoirs of the Royal Academy at Paris for 1781, p. 472; alſo Phil. Tranſ. vol. lxxiv. p. 134.

[¶] Philoſoph. Tranſ. vol. lxxiv. p. 330.

The inference of Mr. Warltire reſpecting the moiſture on the inſide of the glaſs in which Dr. Prieſtley firſt fired inflammable and common air, was, that theſe airs by combuſtion depoſited the moiſture they contained. Mr. Watt however inferred from theſe experiments, that water is a compound of the burned airs, which have given out their latent heat by combuſtion, and communicated his ſentiments to Dr. Prieſtley in a letter dated April 26, 1783[*], and he concludes, that in every caſe wherein dephlogiſticated air was produced, water has been decompoſed by the uſe of ſome ſubſtance, which had a ſtronger attraction to its phlogiſton than is poſſeſſed by the dephlogiſticated air, which is therefore ſet at liberty. He repeated ſome experiments, particularly with a view to decide this point; and in ſeveral of them the quantity of dephlogiſticated air, added to the acid which came over, greatly exceeded the original weight of acid employed. He diſſolved magneſia, calcareous earth and minium reſpectively, in pale nitrous acid, and, on diſtilling to dryneſs, found nearly the whole of the nitrous acid in the retort highly phlogiſticated. From common nitre, the dephlogiſticated air was ſixteen times the weight of the nitrous acid which was miſſing. Mr. Watt has therefore a claim to the merit of a diſcoverer with regard to the compoſition of water, and has the advantage of priority in the diſcovery of its decompoſition.

It does not appear [†] that the compoſition of water was known or admitted in France, till the ſummer of 1783, when M. Lavoiſier and M. de la Place, on the 24th of June, repeated the experiment of burning inflammable and vital air in a glaſs veſſel over mercury, in a ſtill greater quantity than had been burned by Mr. Cavendiſh. The reſult was nearly five gros of pure water [‡]. M. Monge made a ſimilar experiment at Paris, nearly at the ſame time, or perhaps before.

The theory which has been propoſed and explained by M. Lavoiſier, wherein ſuch phenomena as chemiſts have uſually accounted for by the diſengagement or tranſition of phlogiſton are explained, merely by the engagement or contrary tranſition of dephlogiſticated air, or its baſe, by him called the oxygenous or acidifying principle, is amply explained in various parts of our work. See COMBUSTION, PHLOGISTON, PRINCIPLES, the METALS and ACIDS. This theory received a great acceſſion from the diſcovery of the compoſition of water. For it was eaſy to attribute the inflammable air which is diſengaged in many proceſſes to the decompoſition of water, which is undoubtedly preſent in moſt of them, inſtead of ſuppoſing it to come from ſuch bodies as former chemiſts had imagined to contain the principle of inflammability. See ZINC. In the month of September 1783, M. de la Place communicated to M. Lavoiſier [||] his thoughts on the decompoſition of water, which from M. Lavoiſier's former experiments he concluded to take place in metallic ſolutions; and theſe reaſons, added to M. Lavoiſier's own reflections, induced him to purſue the ſubject by a new ſeries of experiments.

This aſſiduous and accurate philoſopher was the firſt who placed a quantity of iron filings and pure water in the upper part of a veſſel inverted over mercury, and obſerved that the iron became calcined, inflammable air being at the ſame time diſengaged, the water being, as he ſays, truly decompoſed *. He then proceeded in conjunction with M. Meuſnier to paſs the ſteam of water through a red hot iron tube, and found that the iron was calcined, and inflammable air diſengaged; and the ſteam of water being paſſed over a variety of other combuſtible or calcinable ſubſtances, produced ſimilar reſults, the water diſappearing and inflammable air being diſengaged. Theſe capital experiments are accounted for by M. Lavoiſier, and ſuch chemiſts as do not admit the exiſtence of phlogiſton, by ſuppoſing the water to be decompoſed into its component parts, vital and inflammable air, the former of which is ſaid to unite with the ignited ſubſtance, while the latter is diſengaged. See Iron, page 406. Conſult alſo the ſecond edition of Kirwan's Phlogiſton, with the Notes of the French Academicians.

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[*] Phil. Tranſ. vol. lxxiv. p. 330. [†] Compare Phil. Tranſ. vol. lxxiv. p. 138. with the Memoirs of the Royal Academy at Paris for 1781, pages 472 and 474. [‡] The ounce poids de marc being 472. 2 grs. troy, this quantity will be 295 Engliſh grains. [||] Memoirs of the Royal Academy at Paris, 1781, p. 476.

The experiment of compoſing water by the combuſtion of vital and inflammable air has been repeated with ſucceſs by the French philoſophers and others; notwithſtanding which, the maintainers of phlogiſton are diſpoſed to doubt or deny the compoſition of water. In certain proportions of the air, and with a rapid combuſtion, nitrous acid and fixed air are produced. The antiphlogiſtian philoſophers affirm, that the former is produced by the azotic air combining with a portion of the vital air, in which it almoſt always exiſts as an impurity. But to this it is objected, that the quantity is too conſiderable, and is not increaſed by the actual addition of azotic air to the mixture before combuſtion. Thoſe who deny the compoſition of water avail themſelves of the very great quantity of this fluid which may be ſuſpended in air. It has been ſtated to be eſſential to the aeriform ſtate, and ſome have gone as far as to conjecture, that the additaments, which together with water form the diſtinct aerial fluids, may be either not ponderable, or in quantity extremely minute. Various conjectural theories have alſo been brought forward relative to the primary or moſt ſimple component parts of nitrous acid and fixed air, which to me appear to require much more mature reflection and deciſive experiment on the part of their authors, before it may be proper to diſcuſs their merits in an elementary work. If the water produced in this capital experiment be ſuppoſed to be merely depoſited from the aerial ingredients, it will be neceſſary that this hypotheſis ſhould be confirmed by ſome facts or experiments upon the airs ſingly, for the purpoſe of ſhewing that they really contain water in ſo large a proportion. But if on the other hand it be affirmed that theſe fluids do combine and afford water, it appears incumbent on the maintainers of this doctrine to make the experiment, with a ſtrict attention to quantity: that is to ſay, the weights of the inflammable and vital airs muſt in the firſt place be accurately determined; and in the next place, the weight of water which they afford by combuſtion, together with that of the reſidue, which eludes that proceſs. A very elaborate apparatus is deſcribed at length, with engravings to admeaſurement, in the Elements of Chemiſtry of Lavoiſier. Its purpoſe is to facilitate the combuſtion of a large quantity of theſe fluids. The principal artifice conſiſts in a double lever or beam, like that of a balance, at one extremity of which, with a proper contrivance for keeping it in the ſame vertical line, is ſuſpended a copper cylinder to be uſed inſtead of the jar of the pneumatic apparatus, with its mouth immerſed in water. At the other end is a

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* Memoirs of the Royal Academy at Paris, 1781, p. 271.

diſh or ſcale, into which weights may be put to regulate the preſſure or force by which this cylinder tends either to riſe or fall. It would require a treatiſe of ſome length, together with engravings, to explain and diſcuſs the methods required to aſcertain the temperature and preſſure of the included fluid, to facilitate the ſupply, and, in a word, to make this delicate and important experiment with the requiſite preciſion. I muſt therefore of neceſſity refer the reader to the laſt mentioned treatiſe, as well as to the 8th and 9th volumes of the Annales de Chimie, where the experiments at large of Fourcroy, Vauquelin, and Seguin are inſerted. And for the ſame reaſon, after giving a ſhort account of their experiments, I ſhall only make a few remarks relative to the cauſes and limits of error, which certainly require a more minute and ſeparate inveſtigation than I can pretend to make in this place. The reſults of the experiments of theſe chemiſts, as I find them in Dr. Pearſon's Tranſlation of the new Nomenclature, which I have compared with the original in the Annales de Chimie, are as under:

To obtain the inflammable air. 1. Zinc was melted and rubbed into a powder in a very hot mortar. 2. This metal was diſſolved in concentrated vitriolic acid diluted with ſeven parts of water. The air procured was made to paſs through cauſtic alkali. To obtain the vital air, two pounds and a half of cryſtallized marine ſalt of vegetable alkali, with exceſs of vital air (ſee p. 27), were diſtilled, and the air was transferred through cauſtic alkali. This experiment was begun on Wedneſday May 13, 1790, and was finiſhed on Friday the 22d of the ſame month. The combuſtion was kept up 185 hours with little interruption, during which time the machine was not quitted for a moment. The experimenters alternately refreſhed themſelves when fatigued, by lying for a few hours on matraſſes in the laboratory.

The volume of inflammable air employed was 25963,563 cubic inches, and the weight was 1039,358 grains.

The volume of vital air was 12570,942, and the weight was 6209,869 grains.

The total weight of both elaſtic fluids was 7249,227.

The weight of water obtained was 7244 grains, or 12 ounces 4 gros 45 grains.

The weight of water which ſhould have been obtained was 12 ounces 4 gros 49,227 grains.

The deficit was 4,227 grains.

The value of azotic or phlogiſticated air before the experiment was 415,256 cubic inches, and at the cloſe of it 467. The exceſs after the experiment was conſequently 51,744 cubic inches. This augmentation is to be attributed, the academicians think, to the ſmall quantity of atmoſpheric air in the cylinders of the gazometers, at the time the other airs were introduced. Theſe additional 51 cubic inches could not ariſe from the inflammable air, for experiment ſhewed that it contained no azotic air. Some addition of this laſt fluid, the experimenters think, cannot be avoided, on account of the conſtruction of the machine.

The water being examined, was found to be as pure as diſtilled water. Its ſpecific gravity to diſtilled water was as 18671 : 18670.

Upon theſe experiments I ſhall remark, 1. That the elaſtic fluids were produced very ſlowly. 2. That the confining medium was water. 3. That the weight of the reſpective quantities of theſe fluids could not be aſcertained by any proceſs applicable to the whole maſs of each, but was deduced by admeaſurement, with corrections for temperature, the preſſure of the atmoſphere, and the arrangement of the apparatus. 4. That this admeaſurement in cubic inches was reduced into weight by the application of an elementary number, expreſſing reſpectively the weight of a cubic inch of each of the fluids. 5. That this elementary number was obtained by an experiment of weighing about 810 cubic inches of each of the fluids in a glaſs globe, the evacuation and repletion of which was effected by means of the air pump. 6. That the glaſs veſſel when empty weighed 24179 grains, and its contents of inflammable air $35\frac{1}{4}$ grains. I ſuppoſe that the $\frac{1}{4}$ grain was the minuteſt quantity capable of being diſcerned by the balance thus loaded; and this being about the 10,000th part of the load in one ſcale, is certainly a conſiderable degree of accuracy. An error of $\frac{1}{4}$ of a grain in this part of the proceſs would affect the number expreſſing the weight of inflammable air in the third figure, without mentioning other cauſes of inaccuracy. That reſult may therefore, at beſt, be conſidered as eſtimate in all the figures but the three firſt. 7. The vital air was near ſixteen times as heavy as the inflammable air, and may therefore, as far as relates to this cauſe of inaccuracy, be admitted nearly to four places of figures. 8. The expanſions and contractions of theſe fluids at different temperatures, were reduced by computation from the experiments of Morveau and Duvernois, which experiments were made upon ſmall quantities only. But on the other hand it muſt be allowed, that this proceſs was ſo managed as to require very little correction on theſe accounts. 9. What may be the limit or magnitude of the errors ariſing from their admeaſurement of cubic inches is not ſo eaſy to determine, becauſe it requires not only information reſpecting the form and magnitude of the meaſures made uſe of, but likewiſe the facility with which the moveable parts of their apparatus adapted themſelves to the variations of circumſtances. This department does not exhibit much probability of error; but ſuch as it may be, it affects the elementary cubic inch uſed in the computations of weight.

Yet upon the whole, as the fidelity of theſe philoſophers cannot be ſuſpected, as the product of water ſo remarkably coincides with the weight of the air which was burned, as there was no veſtige of acid produced, and the reſidue of azotic air was not greater than might be accounted for on the ſuppoſition of original impurity; the experiment may be admitted to prove that vital and inflammable air in certain due proportions do unite at the temperature of moderate combuſtion, and form water. Whether theſe principles may in any other proportion, or at any different temperature, or by any order of arrangement as to primary and ſecondary compoſition, produce any other reſult, are circumſtances which, for any thing we know, are within the limits of poſſibility, but it does not appear from any facts we poſſeſs, that this really happens.

Subſequent to the alledged decompoſition of water by means of iron, Meſſrs. Paets, Van Trooſtwyk and Deiman gave an account of ſome experiments by which they produced gradually a quantity of air from water, and inſtantly cauſed it to diſappear. Their own account is inſerted in the Journal de Phyſique for November 1789. They filled with diſtilled water a glaſs tube $\frac{1}{8}$ of an inch diameter, and 12 inches long, Engliſh meaſure. One extremity of this tube was hermetically ſealed; but at the time of ſealing, a ſmall gold wire was inſerted, and by that means paſſed through the glaſs into the tube for the length of one inch and a half. At the diſtance of $\frac{5}{8}$ of an inch from the end of this wire, another wire was placed in the tube, which came out at the open end into a ſmall veſſel of diſtilled water in which that end was immerſed. For the purpoſe of paſſing the electric commotion through theſe wires, and conſequently through the water between them, the ſealed end of the tube with its wire was applied to an inſulated copper ball at a certain diſtance from the prime conductor of their electrical machine, at the ſame time that the extremity of the other wire, which paſſed through the veſſel filled with water, was made to communicate with the external ſurface of an electrical jar of one foot ſquare, the knob of which touched the prime conductor.

When the electric ſhock was paſſed through the water with a very ſmall interval between the copper ball and the conductor, nothing of conſequence happened; but when the diſtance and conſequently the ſhock was increaſed, ſo that the extremity of each wire became tipped with light, a great number of very minute bubbles of air were produced at each commotion, which had the appearance of a continual flux between the two extremities. This production of air was more conſiderable, and the bubbles at the ſame time larger, when the diſtance between the copper ball and the prime conductor was increaſed, ſo that ſometimes a ſmall ſpark was ſeen to paſs from the upper wire into the water. The air obtained in this manner occupied the upper part of the tube, and gradually increaſed in quantity by the continuance of the proceſs, until the water became depreſſed below the extremity of the upper wire. At this inſtant the electric ſpark, which paſſed through a ſmall portion of the air from the upper wire to the water, ſet fire to the air, preciſely in the ſame manner as happens with a mixture of inflammable and vital air, and the whole diſappeared, excepting a very ſmall reſidue. This reſidue being taken out, the experiment was again repeated with the ſame ſucceſs. The experiment was repeated ſeveral times with the ſame reſult; excepting only, that the reſidue of air after each inflammation appeared to be leſs and leſs.

Several chemiſts found it difficult to repeat this experiment, on account of the facility with which the electric ſhock from wires under water breaks the containing tube. To prevent this effect, theſe philoſophers were careful that the diſtance between the two wires ſhould be too great for a ſpark to paſs from the one to the other. And Dr. Pearſon, before whom the experiment was lately repeated by Mr. Cuthbertſon, aſſerts that the diſcharges were interrupted; by which word electricians commonly underſtand, that part of the circuit is an imperfect conductor. It is probably of conſequence that the ſtream of electricity ſhould be kept up almoſt ſteadily, when the expanſion from the extricated bubbles has once been produced. The plate machine of 32 inches diameter uſed by theſe philoſophers, was ſo powerful, as to occaſion nearly two full exploſions from a ſquare foot of glaſs in each turn. The ſmaller ſhocks here mentioned muſt therefore have been extremely numerous.

Dr. Prieſtley has lately publiſhed in a ſeparate pamphlet, experiments on the generation of air from water. When ſteam is made to iſſue from the end of a glaſs or copper tube into a recipient containing water, every bubble of ſteam collapſes into a ſmall bubble of permanent air. This is generally much purer than common air, and is not found by the teſt of a candle to contain any mixture of inflammable air. There are ſome unaccountable circumſtances attending this experiment. The quantity of air is greatly diminiſhed if the ſteam be paſſed through mercury, even though the mercury be as hot as the ſteam itſelf. The production is alſo much leſs, if the ſteam be condenſed in part before it paſſes into the water, which may be done by cooling the outſide of the pipe. The production does not appear to be affected by the previous purging of the water from air, by boiling or otherwiſe. Dr. Prieſtley varied the experiment, by uſing the ſame water repeatedly confined by mercury. He repeated the proceſs till he was thoroughly ſatisfied, that the air was really produced and not extricated from the water. There is another proceſs, uſed by Dr. Prieſtley, in which air is extricated from water, by filling a glaſs veſſel with that fluid, the neck of which veſſel was narrow and of the length of a barometer tube. When the bulb or body is full and the tube is empty, mercury is poured in till the water riſes to the top of the tube. In this ſituation, the whole is to be inverted over mercury like a common barometer. The mercury then deſcends and occupies the loweſt place, namely the tube itſelf, and the water above it is thus defended from the preſſure of the atmoſphere, more completely than in the vacuum of an air pump. Dr. Prieſtley finds that the water in one of the veſſels in this ſituation, has given out air for upwards of a twelvemonth. Theſe experiments, though looſely related, and given without any numerical indication as to quantity, are curious, and deſerve to be repeated. Whether the quantities of air thus obtained by Dr. Prieſtley were before in a mere ſtate of mixture with the water, as they do not ſeem to have been conſiderable, relative to its bulk or weight; in which caſe his experiments will point out nothing more than a better method of purging water of its air; or whether they lead to new deductions, reſpecting the compoſition of water, muſt, it ſhould ſeem, be decided by additional experiments.

WATERS, MINERAL. The examination of mineral waters with a view to aſcertain their ingredients, and thence their medical qualities and the means of compounding them artificially, is an object of conſiderable importance to ſociety. It is likewiſe a ſubject which deſerves to be attended to, becauſe it affords no mean opportunity for the agreeable practice of chemical ſkill. But this inveſtigation is more eſpecially of importance to the daily purpoſes of life, and the ſucceſs of manufactures. It cannot but be an intereſting object to aſcertain the component parts and qualities of the waters daily conſumed by the inhabitants of large towns and vicinities. A very minute portion of unwholeſome matter daily taken, may conſtitute the principal cauſe of the differences in ſalubrity, which are obſervable in different places. And with regard to manufactures, it is well known to the brewer, the paper-maker, the bleacher, and a variety of other artiſts, of how much conſequence it is to them that this fluid ſhould either be pure, or at leaſt not contaminated with ſuch principles as tend to injure the qualities of the articles they make. This analyſis has accordingly employed the attention of the firſt chemiſts. Bergman has written an expreſs treatiſe on the ſubject, which may be found in the firſt volume of the Engliſh tranſlation of his Eſſays. Fourcroy has written largely on this ſubject, and Chaptal in his Elements of Chemiſtry has given a very conciſe and perſpicuous account of mineral waters, and the methods of examining them. As my own experience has not ſuggeſted to me any addition to the methods collected and pointed out by theſe and other eminent chemiſts; I have thought it beſt in this place to give the method of examination from Wiegleb's General Syſtem.

The topography of the place where theſe waters riſe, is the firſt thing to be conſidered. By examining the ooze formed by them, and the earth or ſtones through which they are ſtrained and filtered, ſome judgment may be formed of their contents. In filtering through the earth, and meandering on its ſurface, they take with them particles of various kinds, which their extreme attenuation renders capable of being ſuſpended in the fluid that ſerves for their vehicle. Hence, we ſhall ſometimes find in theſe waters, ſiliceous, calcareous, or argillaceous earth, and at other times, though leſs frequently, ſulphur, magneſian earth, or, from the decompoſition of aerated iron, ochre. Thus Count Razoumowſki found, that the tepid ſpring at Loeſch, in the Vallais in Switzerland, contained iron impregnated with fixed air; but that this martial ſalt being very eaſily decompoſed, by reaſon of the warmth of the water, remained ſuſpended by means of the inteſtine motion occaſioned by this warmth, and turned the ſilver that was plunged into it, yellow. Beſides the ſubſtances above mentioned, mineral waters contain many others actually diſſolved in them, in abundance, viz. aerial acid or fixed air, mineral alkali, Glauber's ſalt, calcareous and magneſian earth, ſelenite, calcareous and magneſian nitre, vitriol, alum, aerated iron, martial vitriol combined with iron more or leſs calcined, combinations of iron with the muriatic acid, liver of ſulphur, hepatic gas; and finally extractive matter, furniſhed by the bogs through which they may have been ſtrained, before they emerge into the air in the form of ſprings. Vitriol of copper is ſeldom found in mineral waters; it is only in the ſubterraneous waters which flow over copper ores, that veſtiges of it are found. Sedative ſalt has hitherto been found in the water of the lake of Monterotondo only. Arſenic is ſtill rarer, though the ancient chemiſts pretended to have found it in many mineral waters. Inflammable gas being generally the product of putrefaction, is ſeldom found in ſpring waters; and though it is often met with in ſtill waters that ſtagnate on the ſurface, it occurs but very ſeldom in the ſpring itſelf. So likewiſe, the vegetable alkali, being produced by the decompoſition of vegetables, is merely an adventitious ingredient in ſpring waters. The caſe is the ſame with reſpect to vitriolated tartar and nitre; the laſt however occurs more frequently than other matters. Volatile alkali being produced chiefly by the decompoſition of animal ſubſtances, is ſeldomer met with. It is but of late that terra ponderoſa, magneſia, and the different combinations of theſe ſubſtances have been found in mineral waters.

Laſtly, as the acids always tend to combine with other ſubſtances, it is hardly poſſible to find them here in an uncombined ſtate.

From this ſynoptical view of the different ingredients contained in mineral waters, it is evident, that theſe ſubſtances occur in two different diſtinct ſtates, viz. 1. As being ſuſpended in them: and 2. as being diſſolved in them in the form of a ſalt.

The inveſtigation of mineral waters conſiſts: 1. In the examination of them by the ſenſes. 2. In the examination of them by re-agents. 3. In the analyſis properly ſo called.

The examination by the ſenſes conſiſts in obſerving the effect of the water as to appearance, ſmell and taſte.

The appearance of the water, the inſtant in which it is pumped out of the well, as well as after it has ſtood for ſome time, affords ſeveral indications, from which we are enabled to form a judgment concerning its contents. If the water is turbid at the well, the ſubſtances are ſuſpended only, and not diſſolved; but if the water is clear and tranſparent at the well, and ſome time intervenes before it becomes turbid, the contents are diſſolved by means of fixed air.

The preſence of this gas is likewiſe indicated by ſmall bubbles that riſe from the bottom of the well, and burſt in the air while they are making their eſcape, though the water at the ſame time perhaps has not an acid taſte. This is the caſe, according to Count Razoumowſki, with reſpect to the tepid ſpring in Vallais, and the cold vitriolated chalybeate ſprings at Aſtracan. But the moſt evident proof of a ſpring containing fixed air, is the generation of bubbles on the water being ſhaken, and their burſting with more or leſs noiſe, while the air is making its eſcape.

The ſediment depoſited by the water in the well is likewiſe to be examined; if it be yellow, it indicates the preſence of iron; if black, that of iron combined with ſulphur; but chalybeate waters being ſeldom ſulphurated, the latter occurs very rarely. As to the colour of the water itſelf, there are few inſtances where this can give any indication of its contents, as there are not many ſubſtances that colour it.

The odour of the water ſerves chiefly to diſcover the preſence of ſulphur in it: ſuch waters as contain this ſubſtance, ſmell of liver of ſulphur, or rotten eggs.

The taſte of a ſpring, provided it be perfectly aſcertained by repeated trials, may afford ſome uſeful indications with reſpect to the contents. It may be made very ſenſible by taſting water, in which the various ſalts that are uſually found in ſuch waters are diſſolved in various proportions. There is no certain dependance however to be placed on this mode of inveſtigation; for in many ſprings, the taſte of Glauber's ſalt is diſguiſed by that of the ſea ſalt united with it. The water too is not only to be taſted at the ſpring, but after it has ſtood for ſome time. This precaution muſt be particularly obſerved, with reſpect to ſuch waters as are impregnated with fixed air; for the other ſubſtances contained in them make no impreſſion on the tongue, till the fixed air has made its eſcape; and it is for the ſame reaſon that theſe waters muſt be evaporated in part, and then taſted again.

Though the ſpecific gravity of any water contributes but very little towards determining its contents, ſtill it may not be entirely uſeleſs to know the ſpecific weight of the water, the ſituation of the ſpring, and the kind of ſediment depoſed by it.

The examination of the water by means of re-agents ſhews what they contain, but not how much of each principle. In many inſtances this is as much as the enquiry demands; and it is always of uſe to direct the proceedings in the proper analyſis.

It is abſolutely neceſſary to make the experiment with water juſt taken up from the ſpring, and afterwards with ſuch as has been expoſed for ſome hours to the open air; and ſometimes a third eſſay is to be made with a portion of the water that has been boiled and afterwards filtered. If the water contains but few ſaline particles, it muſt be evaporated; as even the moſt ſenſible re-agents, ſuch as the ſolution of ſilver, and the ſalts formed by the union of the terra ponderoſa with the nitrous and muriatic acids do not in the leaſt affect it, if the ſalts whoſe preſence is to be diſcovered by them are diluted with too great a quantity of water. Now, it may happen, that a water ſhall be impregnated with a conſiderable number of ſaline particles of different kinds, though ſome of them may be preſent in too ſmall a quantity: for which reaſon the water muſt be examined a ſecond time, after having been boiled down to three fourths.

The ſubſtances of which the preſence is diſcoverable by re-agents, are:

A. Alkalis and earths combined with aerial acid.

Paper ſtained with brazil wood, will diſcover the preſence of theſe ſubſtances in the water: if the water contains the ſmalleſt portion of alkali, they will change its red hue into a colour partaking more or leſs of the violet. A ſtill greater degree of ſenſibility is ſhewn, according to Mr. Watt's experiments, by the tincture of the leaves of the braſſica rubra, as well as by that of roſe leaves.

(a) *Alkaline ſalts.*

The taſte is ſometimes ſufficient to indicate their preſence in mineral waters impregnated with aerial acid, after theſe waters have been expoſed to the air for ſome time; but for the ſake of producing abſolute conviction, let a paper ſtained with turmeric be dipped in the water previouſly warmed, the colour of this is changed by alkaline ſalts only, and not by earths; now if the colour of the paper is changed, and a quantity of ſal ammoniac put into the water produces a ſmell of volatile alkali, the water certainly contains fixed alkali.

(b) *Abſorbent earths.*

Water which does not change the colour of paper ſtained with brazil wood or litmus, and which, after having been boiled, does not render lime water turbid, contains abſorbent earth: if this earth be of a calcareous nature, it will be precipitated by the acid of ſugar, provided the water be taken freſh from the pump: but not after it has been boiled, unleſs indeed a particle or two of this earth ſhould be diſſolved in another acid, but in this caſe the ſediment will not be nearly ſo conſiderable as in the other. The caſe is the ſame with reſpect to barytes, or terra ponderoſa.

(c) *A mixture of alkaline ſalts and earth.*

The water having been examined in the above-mentioned method for the purpoſe of diſcovering the alkaline ſalt in it, let part of this water be made warm; if it becomes turbid, there is certainly, excluſively of the alkali, an earth diſſolved in it by means of fixed air; beſides which, it is poſſible the alkali may hold another portion of earth ſuſpended.

B. *Neutral ſalts in general.*

The pureſt vinous ſpirit ſerves to diſcover their preſence; but for the ſake of aſcertaining that the ſubſtance precipitated by it, is a ſalt perfectly neutralized, the water muſt be filtered, as ſoon as the ſubſtance has ſettled, and when the ſpirit is evaporated, the reſiduum muſt be taſted; the taſte will be ſufficient to direct the experimenter, with reſpect to the choice of his re-agents.

(a) *Vitriolic ſalts in general.*

A few drops of the ſolution of terra ponderoſa in the muriatic acid, will be ſufficient to diſcover the ſmalleſt particle of any vitriolic ſalt; the acid of which will fall down combined with the terra ponderoſa in the baro-ſelenite, or barytic vitriol.

(b) *Muriatic ſalts in general.*

Waters containing theſe ſalts, throw down from a ſolution of ſilver in nitrous acid, a white precipitate (luna cornea) which is inſoluble in nitrous acid.

(c) *A mixture of muriatic and vitriolic ſalts.*

Firſt, let a ſolution of the terra ponderoſa in nitrous acid be poured into the water till nothing more be precipitated from it; the precipitate being ſeparated, let a ſolution of ſilver be poured into the filtered liquor, till it ceaſes to yield any precipitation. The former of theſe precipitates indicates the preſence of vitriolic, the ſecond, that of muriatic ſalts; and the difference in the quantity of the ſediments ſhews the different proportion of theſe ſubſtances in water.

C. *Earthy ſalts.*

Alkali ſaturated with fixed air, precipitates the earth out of all earthy and metallic ſalts. But to know whether this precipitate be of a metallic, or merely of an earthy nature, the experiment muſt be made with the Pruſſian alkali. If this throws down no precipitate, the former ſediment was mere earth.

(a) *Calcareous ſalts.*

A few grains of the acid of ſugar will diſcover theſe ſalts, provided that the water containing them has been previouſly boiled; if a precipitate is formed, there is no doubt of their preſence.

(b) *A mixture of calcareous earth and calcareous ſalts.*

In order to aſcertain their preſence, the water muſt be boiled; if during the boiling an earth is thrown down, which after having been diſſolved in the acetous acid, forms a precipitate with the acid of ſugar, and if the water yields at the ſpring a ſtill greater ſediment with the acid of ſugar, it contains, beſides a calcareous ſalt, a portion of calcareous earth.

(c) *A mixture of calcareous earth with ſalts, in which another earth is contained.*

Let a ſmall quantity of a ſolution of acid of ſugar be poured into the water; if it contains calcareous earth, a precipitation will enſue. To the ſuperincumbent water, after it has been decanted off from the earth and filtered, a ſolution of alkali ſaturated with fixed air muſt be added. If another precipitation enſues, there is, beſides the calcareous earth, another earthy ſalt in the water. For the purpoſe of diſcovering it, a little diluted acid of vitriol muſt be poured upon the precipitate, which without cauſing any effervеſcence will form Epſom ſalt, if the precipitate be muriatic earth; regenerated heavy ſpar, if it be terra ponderoſa; and alum, if it conſiſts of earth of alum.

(d) *Muriated or aerated barytes.*

If the water be ſuppoſed to contain at the ſame time terra ponderoſa combined with fixed air, and the ſame earth in a perfectly ſaline ſtate, means muſt be uſed analogous to thoſe that are employed for the diſcovery of calcareous earth; which is, to boil the water; to diſſolve the earth which precipitates in the marine acid; and then try whether the vitriolic acid will produce a precipitate; if it does, the water contains terra ponderoſa aerata. After this, let ſome vitriolic acid be mixed with diſtilled boiling water; when, if a precipitate is formed, it is owing to the muriatic ſalt of the terra ponderoſa contained in the water.

(e) *Alum.*

The moſt ſimple means of diſcovering whether water of any kind contains alum, are, to boil the water in a very clean copper veſſel, when, if it contains alum, it will exhibit a blue colour. When the quantity of alum in the water is ſmall, the blue colour is not ſenſible; but it may be rendered very manifeſt by the addition of a little cauſtic volatile alkali. This method of diſcovering alum in water by means of copper, is founded on the property of this ſalt, in virtue of which it always exiſts with an exceſs of acid: it is this ſurplus of acid which acts upon the copper. A more certain method is to pour a ſolution of fixed alkali into the water, and to ſee whether the precipitate made by this means diſſolves in water impregnated with fixed air; if it does, it is not earth of alum.

D. *Metallic ſalts.*

Nothing is better adapted to the purpoſe of diſcovering the preſence of metallic ſalts in waters, than the Pruſſian alkali purified by acids. If a ſolution of this alkali be poured into this water, after it has been expoſed for ſome time to the air filtered, it makes a precipitate, which will be blue, if the water contains iron; brown, if it contains copper; and white, if it contains zinc. In caſe the Pruſſian alkali is not at hand, a ſolution of fixed alkali may be uſed in its ſtead. This with iron forms a yellow; with copper, a green; and with zinc, a white precipitate. This laſt precipitate becomes yellow, when expoſed to the action of the fire.

(a) *Aerated iron.*

Water which contains aerated iron has its colour changed by an infuſion of galls, but not by the Pruſſian alkali; however, after ſuch water has been expoſed for ſome time to the air, the iron is precipitated out of it, and it ceaſes to be affected by this infuſion. If a water excluſively of this aerated iron contains an alkaline ſalt, the colour ſtruck by the infuſion of galls is rather red than violet.

Iron not much calcined and diſſolved in mineral acids.

Iron calcined to a certain point, will diſſolve in vitriolic acid; but if it has been too much, it is not ſoluble in this, although it be in the muriatic acid. If the iron contained in the water be in this latter ſtate, the water will be made blue by the Pruſſian alkali, but will not be affected by an infuſion of galls. In a water of this kind, let a piece of poliſhed ſteel be ſteeped, and the water evaporated till it is reduced to one half. Now, acids having more affinity with iron, while it retains its metallic ſtate, than after it has been deprived of it, the iron in the former ſtate will expel that in the latter, and at the ſame time partly reduce it; and thereby enable it to ſtrike a black or deep purple colour with an infuſion of galls.

(d) *Iron in two different ſtates in the ſame water.*

A water of this kind depoſits ochre, a ſhort time after it is expoſed to the air, and yields at the ſpring, with Pruſſian blue, a green or olive-coloured precipitate.

E. *Cupreous ſalts.*

Water which contains theſe ſalts, acquires a diſtinct blue colour from a few drops of volatile alkali, and yields a brown precipitate by the addition of a little phlogiſticated alkali.

F. *Salts of zinc.*

Water that contains theſe ſalts affords with Pruſſian blue a white precipitate, which becomes yellow in the fire, and turns white again as ſoon as it is cold.

G. *Arſenic.*

If this ſubſtance be contained in the water, it will be diſcovered by pouring a ſolution of volatile liver of ſulphur into the water, from which it will be precipitated of a yellow colour. A ſolution of gold may likewiſe be uſed for this purpoſe. The water may likewiſe be boiled down, and the reſiduum be thrown upon live coals; if it ſmells of garlic the water contains arſenic.

H. *Combination of acids with mangeneſe.*

If, on a little of a ſolution of vegetable alkali being poured into water, a white precipitate is formed, and if the precipitate becomes black in the fire, and is ſoluble neither in the nitrous nor vitriolic acid, the water contains manganeſe.

I. *Liver of ſulphur.*

Nitrous acid deſtroys the odour of the waters which contain theſe ſubſtances, and ſeparates the ſulphur. On the other hand, the vitriolic and common marine acids augment the ſmell, while they ſeparate the ſulphur. But if it be requiſite to render the ſulphur viſible, the experiment muſt be made with a conſiderable quantity of water, and the whole ſuffered to ſtand undiſturbed for ſome time. The ſolutions of lead, ſilver, and quickſilver in nitrous acid, and the ſolution of corroſive ſublimate, yield with a water of this kind a brown or elſe a black precipitate; which, when dried, will burn, on a red hot ſhovel, with a blue flame and a ſulphureous ſmell.

K. *Hepatic air.*

The pure vitriolic and the phlogiſticated marine acids neither augment nor diminiſh the odour of the water that contains this air; they likewiſe neither render it turbid, nor do they precipitate the ſulphur; this laſt is effected by the dephlogiſticated nitrous and marine acids, though in a very ſmall quantity only. At the ſame time too they deprive the water of its offenſive odour. The ſolutions of quickſilver, lead, and ſilver, do not yield any precipitate, except there is a conſiderable quantity of this air employed; and what is more extraordinary, this precipitate does not burn with a flame. The ſolution of corroſive ſublimate, and the nitrous ſolution of quickſilver made with heat, give with this kind of water a white precipitate. The calx of ſilver turns black in it, and deprives it of its offenſive odour; it loſes this ſmell likewiſe in a copper veſſel, after remaining in it a minute or two.

In order to obtain a water ſaturated with ſulphureous gas, Dr. Hahneman expoſes to a white heat, for a few minutes only, a pounded mixture of equal parts of ſulphur and unſlaked or freſh ſlaked lime; and throwing half an ounce of this with five drachms of purified tartar into a bottle containing two pounds of pure luke-warm water, ſtops it quickly with a cork; and after ſhaking it for ten minutes, and allowing the groſſer particles to ſettle, pours off the milky liquor into another bottle, and mixes it by agitation with three or four tea-cups of thick cream, or half an ounce or two ounces of gum arabic, or half an ounce of gum tragacanth bruiſed. Calcareous hepar requires 1920 parts of cold, and 840 of warm water: calcareous tartar 800 of cold, and 500 of warm, for their ſolution.

For a warm bath he takes fourteen ounces of calcareous hepar, and one pound of cream of tartar pounded, and ſtirs them up in the water of the bathing-tub; or, in 300lb. of water made warm to 100 degrees, he agitates three quarters of a pound of hepar, made with pot-aſh, and then ſtirs up with it very briſkly a quarter of a pound of ſtrong oil of vitriol.—Or he takes four parts of ſcales of iron fuſed with three of ſulphur, till it ceaſes to yield a blue flame; puts half a pound of this mixed with five pounds of water, into a bottle holding eight or ten pounds; on this he then pours a quarter of a pound of oil of vitriol, inſtantly ſtopping it with a bladder tied over and pricked with a needle; ſinks it to the bottom of a high bathing-tub, filled with warm water, and mixes the air as it comes out by agitation with the water. Vid. Chem. Annal. ii. Stuck 1788. Alſo Hahneman, ubem die Arſenickvergifung. Leipſick, 1786.

L. *Fixed Air.*

Waters which contain fixed air, change the colour of tincture of litmus to red but this colour muſt be carefully diſtinguiſhed from the reddiſh hue exhibited by this tincture when diluted with a great quantity of water, from which it is very different. According to Profeſſor Bergman's method, lime water may likewiſe be uſed, a practice which however ſtands in need of ſome improvement. When a water contains a certain but ſmall quantity of fixed air, it does not change the colour of the infuſion of litmus; and in this caſe the quantity muſt be aſcertained by diſtilling the water in a pneumatic apparatus. The taſte of the water indicates the preſence of this ſubſtance, only when the water contains a certain quantity of it; for it is by no means to be inferred, when the water does not taſte ſour, that it contains no fixed air; at the contrary circumſtance ſometimes takes place. A water of this kind generates bubbles at the ſpring, which burſt at its ſurface with ſome noiſe.

The analyſis of mineral waters ſhews in the firſt place, how much of each of theſe ſubſtances is contained in the water; and it is performed by evaporating the water, by which means one ſubſtance is obtained after another, when each of them is weighed ſeparate. Some mineral waters contain volatile particles, which make their eſcape during the evaporation of the water; others contain ſuch ſubſtances as are liable to be decompoſed by evaporation, or may more or leſs prevent the developement of the other parts.

Laſtly, all of them contain fixed ſubſtances, that remain behind in a dry and concrete ſtate, after the water is evaporated.

A. *Separation of the volatile ſubſtances.*

(*a*) *In water which contains hepatic air, theſe ſubſtances occur.*

If nitrous acid be poured on a portion of this kind of water, the quantity of ſulphur precipitated by it, gives the quantity of the hepatic air contained in the water; each cubic inch of the latter containing a quarter of a grain of ſulphur.

(*b*) *Water ſeparated with fixed air.*

Part of ſuch water is to be evaporated in the method deſcribed a little farther on. From another portion of it, according to Profeſſor Bergman, the air is to be expelled, and afterwards mixed with lime water for the purpoſe of aſcertaining the quantity of it. If Bergman's preſcription be followed literally, the fixed air will be loaded with vapours of the water, which will paſs with it through the mercury, be condenſed on its ſurface, and afterwards abſorb part of the air. It is better to paſs the air immediately through lime water; for in this caſe, one part precipitates along with the calcareous earth which it meets with in its paſſage, as does likewiſe the remainder if the apparatus be ſhaken a little. This earth too muſt be carefully ſeparated by filtration. Now as the quantity of fixed air contained in calcareous earth, and its ſpecific gravity, is very well known, it is very eaſy to make an accurate eſtimate of the quantity of fixed air that is contained in the water; for inſtance, if half a dram of calcareous earth be obtained, the water contains $18\frac{3}{4}$ grains of fixed air, or $32\frac{89413}{1000000}$ cubic inches; allowing with Kirwan, a cubic inch of fixed air to weigh $\frac{57}{100}$ of a grain.

In default of a pneumatic apparatus, provided it be certain that the water does not contain any fixed alkali, it needs only to be mixed with four times its quantity of lime water, and then filtered.

If the water contains alkali, the experiment muſt be made twice, viz. firſt at the ſpring, and afterwards when the water has been boiled; the weight of the ſecond ſediment is then to be ſubtracted from that of the firſt, viz. of the aerated earth, and it will appear what allowance is to be made for the weight of the fixed air.

B. *Analyſis of the volatile alkaline ſubſtances.*

If a ſubſtance of this kind be ſuſpected in the water, let part of it, after having been weighed, be put in a retort, and about one-third of it drawn off by diſtillation; a quantity of marine acid is then to be poured on the diſtilled portion, till the ſaturation is complete: the ſal ammoniac thus obtained is then to be dried and weighed; the quantity of acid in the ſal ammoniac being known, it is eaſy to eſtimate that of the volatile alkali in the water. Wenzel's eſtimate of the volatile alkali contained in ſal ammoniac, ſeems to be more exact than that of Bergman. If theſe waters contain particles that may be either eaſily decompoſed, or alter the product of the analyſis, they muſt be treated in the following method:

C. *Separation of the ſubſtances which are decompoſed during the evaporation of the water, and which prevent the ſeparation of the other ingredients.*

Theſe ſubſtances are, liver of ſulphur and metallic ſalts. The acid of ſulphur which was diſengaged during the evaporation, combines with the alkaline ſubſtances that may happen to be contained in the water, and changes their nature. In metallic ſalts the metal becomes calcined, ſeparates from its acid, and enters into new combinations with the other ingredients of the water. Hence the liver of ſulphur, as well as the metallic ſalts, muſt be decompoſed, and an eſtimate made of the quantity in which they are preſent in the water previous to undertaking the evaporation.

(a) Water that contains liver of ſulphur.

For the purpoſe of analyſing a water that contains liver of ſulphur, a quantity of nitrous acid muſt be poured into it ſufficient to precipitate all the ſulphur. The precipitate is then to be ſeparated and weighed.

(b) Water that contains metallic ſalts.

Pour into this water a ſolution of Pruſſian alkali, previouſly purified by means of nitrous acid; as ſoon as the precipitation ceaſes, the water muſt be filtered, and the precipitate drained and weighed.

D. *Separation of the fixed and unchangeable ſubſtances.*

The ſeparation of the volatile bodies, and of ſuch as may prevent the ſeparation of the fixed and unchangeable ſubſtances, having been effected; let a certain quantity of the water be weighed, and, after being evaporated to dryneſs, weighed again. The evaporation is beſt performed in veſſels of glaſs or china. It is true that a gentle heat only can be uſed with ſuch veſſels, and that conſequently the evaporation goes on but ſlowly in them. But this inconvenience is balanced by the certainty the operator has no other matter united with it.

In whatever manner the evaporation is performed, the reſiduum conſiſts of ſalts which are ſoluble in the pureſt ſpirit of wine, of ſuch as are ſoluble in cold water, and of ſuch ſubſtances as cannot be diſſolved by either of theſe menſtrua. The firſt thing therefore to be done, is to pour a quantity of rectified ſpirit of wine on the reſiduum, and let them digeſt together for the ſpace of a few hours in a gentle heat. The liquor is then to be decanted into another veſſel, in order that its contents may be further analyſed, and in the mean time the analyſis of the remainder is to be continued. With this view, a quantity of cold water is to be poured upon the reſiduum, which muſt ſtand in a gentle heat for the ſpace of ſix or eight hours, and be ſhaken now and then. The water is then to be decanted off into another glaſs, and ſome freſh water added to the remainder; after ſtanding one or two hours longer, the water in both glaſſes is to be mixed and filtered, and ſet apart for the purpoſe of examining its contents. Theſe conſiſt of ſalts perfectly neutralized, and vitriolic ſalts, excluſively of ſelenite. That part of the reſiduum which is inſoluble in water and ſpirit of wine, conſiſts of different earths, of the ſelenite, and of the iron that has been diſſolved in the fixed air of the water. The bodies which have been diſſolved in both liquids, are now to be ſeparated from each other, as muſt the ſubſtances that compoſe the undiſſolved reſiduum.

A. Separation of the ſubſtances diſſolved in the ſpirit of wine.

Theſe may be either ſedative ſalt, common ſalt, nitrous acid combined with an earth, arſenic, or extractive matter.

There are three methods of ſeparating theſe ſubſtances.

Firſt method.

(a) For ſedative ſalt.

The vinous ſpirit is to be mixed with twice its quantity of diſtilled water, and part of this mixture evaporated; if this be ſuffered to cryſtallize, ſedative ſalt is obtained, of all the ſalts that are ſoluble in ſpirit of wine the only one that is cryſtallizable.

(b) Salts with a calcareous baſis.

If the re-agents indicate a calcareous ſalt in the water, the calcareous earth is to be ſeparated by the acid of ſugar ſaturated with alkali. The quantity of the precipitate thus obtained, gives the quantity of the calcareous ſalt contained in the water. The ſalt acquired by cryſtallization, whether it be nitre or digeſtive ſalt, ſhews with what acids the calcareous earth is combined. In order to ſeparate this ſalt more accurately, the liquor may be evaporated to dryneſs, and the ſoluble part of the reſiduum extracted with ſpirit of wine; conſequently the digeſtive ſalt and cubic nitre, being inſoluble in the ſpirit, are left behind. After theſe are ſeparated, the ſpirit muſt be diluted with diſtilled water, and the undiſſolved ſubſtances ſeparated by the method mentioned below.

(c) Salts, the baſis of which is heavy earth, or barytes.

If, in conſequence of the analyſis made with the re-agents, the preſence of a ſalt of this kind is ſuſpected in the water, let a ſolution of Glauber's ſalt, or vitriolated tartar, be poured into the water. After this, either the digeſtive ſalt, or the nitre, whichſoever it be, that is formed by this decompoſition, muſt be ſeparated.

(d) Salts, the baſis of which is magneſian earth.

If the water contains a portion of theſe ſalts, there muſt be added a quantity of fixed alkali to the liquor that is left after the preceding experiment. The conſequence of this will be, that the magneſia will be precipitated; and from the cryſtals, either of digeſtive ſalt or nitre, which may be ſeparated either by cryſtallization or precipitation with ſpirit of wine, it will appear with what acid the earth was united. If the weight of theſe laſt ſalts, or that of the precipitated earth, be known, the quantity of Epſom ſalt in the water may be eaſily eſtimated.

(e) Arſenic.

If there be any reaſon to ſuſpect this ſubſtance in the water, to the above-mentioned liquor, before it is ſuffered to cryſtallize, a ſmall quantity of volatile liver of ſulphur may be added; the arſenic will ſpeedily unite with the ſulphur, and afterwards the digeſtive ſalt, or the nitre, whichſoever of theſe is preſent, may be ſeparated from the liquor.

(f) Extractive matter.

Laſt of all, the extractive matter muſt be ſeparated from the ſpirit of wine. With this view, the liquor that remains after theſe various proceſſes muſt be evaporated to dryneſs. Some particles of it however adhere to the cryſtallized ſalts, as do likewiſe ſome ſaline particles to the extractive matter.

Second method.

This method is founded on the obſervation that, except arſenic, and ſedative ſalt, all others which ſpirit of wine is capable of holding in ſolution contain an earth. The vinous ſpirit charged with thoſe ſubſtances, being mixed with a ſufficient quantity of water, and the arſenic and ſedative ſalt being thus ſeparated from it, let a ſolution of ſilver in nitrous acid be poured into it; the precipitate hereby obtained indicates the quantity of marine acid that was preſent in the water combined with the earth. The remainder of the liquid is then to be precipitated with fixed alkali: a more preciſe analyſis of the earth obtained, will ſhew the nature and quantity of the ſalts of which it made a component part.

If beſides theſe there are in the water other ſalts, the earth of which is combined with nitrous acid, in this caſe the quantity of the earth obtained will not correſpond with that of the marine acid, as indicated by the ſolution of ſilver. But as all ſalts in which the marine acid is combined with an earth, contain nearly the ſame quantity of earth, nothing more is neceſſary to be done, than to ſubtract from the earth obtained by the foregoing proceſs, the quantity ſufficient to ſaturate the marine acid in a liquid ſtate, and the remainder will give the weight of the earth diſſolved in the nitrous acid.

For the purpoſe of aſcertaining the nature and quantity of the earth obtained, let the precipitate made by the fixed alkali be diſſolved in nitrous acid, to which muſt be added, drop by drop, a ſmall quantity of a ſolution of acid of ſugar, ſaturated with fixed alkali. In conſequence of this, the calcareous earth will be precipitated and combined with the acid of ſugar, and the weight of the precipitate will point out the quantity of the calcareous earth contained in the liquor. Now, if after this liquor be ſeparated from this precipitate by decantation, and a ſolution of alkali, ſaturated with fixed air, be poured into it, the muriatic and aluminous earth will be likewiſe precipitated. Laſtly, let there be poured upon this mixture a quantity of diſtilled water, ſaturated with fixed air: the former of theſe earths will be diſſolved, while the latter will be left undiſſolved.

Third method.

The arſenic and ſedative ſalt being ſeparated, let the remaining liquor be diluted with three times its quantity of water, and the earth precipitated from it with fixed alkali; the liquor being decanted off from the earthy precipitate, which muſt be analyſed in the method abovementioned. Let there be poured into the former a ſmall quantity of ſolution of ſilver. The weight of the precipitate here produced, ſhews the quantity of marine acid that was combined with the earth.

B. *Separation of the ſubſtances that are ſoluble in diſtilled water.*

Theſe may be fixed alkali ſaturated with fixed air, all the perfect neutral ſalts, alum, Epſom ſalt, and other ſalts.

(a) Fixed alkali.

It is hardly poſſible to aſcertain the quantity of mineral alkali that is contained in any water by the cryſtallization of this ſalt; for ſome part of it always mixes with the other ſalts, and it can never be obtained in a pure ſtate. Let therefore any quantity of Epſom ſalt, but rather more than is ſufficient, be taken to ſaturate the alkali in the water. The water will become turbid, and in the ſpace of five or ſix hours let fall a quantity of muriatic earth. But the redundant quantity alſo of the Glauber's ſalt that may exiſt in the water, as well as that of the Epſom ſalt employed in this proceſs, muſt be taken into conſideration. Theſe are the only means on which any dependance can be placed in analyſing alkaline waters.

(b) Alum and Epſom ſalt.

If theſe ſalts are found together in the water, either with or without any other ſalt, the beſt mode of aſcertaining the quantity of them, is to decompoſe them; thus let a ſolution of fixed alkali be added drop by drop to the water, till it ceaſes to render the water turbid. The precipitate being waſhed, dried and weighed, a quantity of diſtilled water ſaturated with fixed air muſt be poured upon it, which will diſſolve the magneſian but not the aluminous earth; the weight of the latter ſubtracted from the whole of the precipitate will give the weight of both earths. The analyſis is to be continued, and the vitriolated tartar formed by the decompoſition muſt be ſeparated. This may be eaſily done by cryſtallization.

If the Epſom ſalt be mixed with Glauber's ſalt, it is almoſt impoſſible to ſeparate them by cryſtallization, as both of them cryſtallize at the ſame time. Here, as before, recourſe muſt be had to the decompoſition of them. The portion of Glauber's ſalt contained in the water may be determined by the weight of the precipitated earth; the ſame holds good with reſpect to alum, when mixed with other ſalts.

(c) Glauber's ſalt, common ſalt, and nitre.

1. A ſolution of terra ponderoſa in nitrous acid is to be poured into water that has ſtood ſome time on the reſiduum of the evaporated water, and the precipitate dried and weighed. By this means the quantity of Glauber's ſalt contained in the water will be aſcertained.

2. Into this water that has been ſeparated from the abovementioned precipitate by filtration, let a quantity of ſolution of ſilver in nitrous acid be poured; this will cauſe a precipitate, which muſt be ſeparated from the ſupernatant liquid, and, when dry, weighed for the purpoſe of diſcovering the quantity of common ſalt contained in the water.

3. If the weight of the Glauber's ſalt, and common ſalt, taken together, be ſtill not equal to that part of the reſiduum that has been diſſolved in cold diſtilled water, this circumſtance gives room to ſuſpect that there is nitre in it, the quantity of which is diſcoverable by the difference of the others.

C. Separation of the ſubſtances contained in that part of the reſiduum of the water, which is not ſoluble either in ſpirit of wine, or in cold water, viz. ſelenite, iron, ſiliceous, aluminous, magneſian, calcareous, and ponderous earth.

I. Selenite. The reſiduum, after being weighed, is to be boiled with five hundred times its weight of diſtilled water; the ſelenite will be diſſolved, and will paſs through the filter with the water, while the iron and the earth will remain behind. The remainder muſt now be dried upon the filter, and weighed; if the weight be ſubtracted from its former weight before it was boiled, it will give that of the ſelenite.

In order to ſeparate the ſelenite, marine acid may likewiſe be poured on the reſiduum; the acid will diſſolve the iron and the earths, and the ſelenite will remain behind, together with a little ſiliceous matter. For the purpoſe of aſcertaining the quantity of the latter, nothing more is neceſſary than to waſh the reſiduum with diſtilled water; what remains after this is ſiliceous earth, the quantity of which is eaſily determined.

II. Siliceous earth. The ſelenite being ſeparated in the former of theſe methods, upon what remains on the filter after it has been dried and weighed, pour a quantity of marine acid, when it will all diſſolve except the ſiliceous earth, and the deficiency in the weight will determine the quantity of this earth.

III. Iron. Into this ſolution let there be poured a little Pruſſian alkali purified by means of marine acid, the iron will be precipitated in the form of Pruſſian blue.

The Pruſſian alkali muſt be previouſly purified by acids, in order to prevent the precipitation of the earthy ſalts, and to make the precipitate charge itſelf more perfectly with the colouring matter. In Profeſſor Bergman's method, the ſiliceous earth combines with the alkali, and in this caſe it is very difficult to aſcertain the quantity of it.

IV. Calcareous earth. After the ſeparation of the iron by means of the Pruſſian alkali, the liquor is ſtill charged with different kinds of earths. In order to ſeparate the calcareous earth from this liquor, a ſolution of acid of ſugar ſaturated with alkali muſt be added drop by drop, when the calcareous earth will be precipitated in the form of calx ſaccharata, or calcareous ſaccharine ſalt.

V. Magneſian and aluminous earths.

In order to obtain theſe earths from the liquor ſtanding upon the calcareous ſaccharine ſalt, a ſolution of fixed alkali is to be added to it, till the precipitation ceaſes; the precipitate, which conſiſts either of earth of alum, or magneſian earth, or both together, is then to be waſhed, dried, weighed, and put into a large bottle that is perfectly air-tight, and the bottle is to be filled with diſtilled water perfectly ſaturated with fixed air; this will diſſolve the magneſian earth, and leave the aluminous earth behind.

WATERS, SPIRITUOUS. Spirituous liquors to which a flavour is given by infuſion of herbs, diſtillation from fragrant vegetables, ſolution of eſſential oils, ſugar, or other ingredients, have been called ſtrong waters. This term was formerly more generally applied than at preſent.

WAX, is an oily concrete matter gathered by bees from plants.

Wax has been long conſidered as a reſin, from ſome properties common to it with reſins. It has the ſame conſiſtence as reſins have, and like them, it furniſhes an oil and an acid by diſtillation, and is ſoluble in all oils; but in ſeveral reſpects it differs ſenſibly from reſins. Like theſe, wax has not a ſtrong aromatic taſte and ſmell, but a very weak ſmell, and when pure, no taſte. With the heat of boiling water no principles are diſtilled from it; whereas, with that heat, ſome eſſential oil, or at leaſt a ſpiritus rector, is obtained from every reſin. Further, wax is inſoluble in ſpirit of wine. If wax be diſtilled with a heat greater than that of boiling water, it may be decompoſed, but not ſo eaſily as reſins can. By this diſtillation a ſmall quantity of water is firſt ſeparated from the wax, and then ſome very volatile and very penetrating acid, accompanied with a ſmall quantity of a very fluid and very odoriferous oil. As the diſtillation advances, the acid becomes more and more ſtrong, and the oil more and more thick, till its conſiſtence be ſuch that it becomes ſolid in the receiver, and is then called butter of wax. When the diſtillation is finiſhed, nothing remains but a ſmall quantity of coal, which is almoſt incombuſtible.

Wax cannot be kindled, unleſs it be previouſly heated and reduced into vapours; in which reſpect it reſembles fat oils. The oil of butter of wax may by repeated diſtillations be attenuated and rendered more and more fluid, becauſe ſome portion of acid is thereby ſeparated from theſe ſubſtances; which effect is ſimilar to what happens in the diſtillation of other oils and oily concretes: but this remarkable effect attends the repeated diſtillation of oil and butter of wax, that they become more and more ſoluble in ſpirit of wine; and that they never acquire greater conſiſtence by evaporation of their more fluid parts. Boerhaave kept butter of wax in a glaſs veſſel open, or careleſsly cloſed, during twenty years, without acquiring a more ſolid conſiſtence. It may be remarked, that wax, its butter, and its oil, differ entirely from eſſential oils and reſins in all the above-mentioned properties, and that in all theſe they perfectly reſemble ſweet oils. Hence Macquer concludes, that wax only reſembles reſins in being an oil rendered concrete by an acid; but that it differs eſſentially from theſe in the kind of the oil, which in reſins is of the nature of eſſential oils, while in wax and in other analogous oily concretions (as butter of milk, butter of cocoa, fat of animals, ſpermaceti, and a wax obtained from a tree in Louiſiana) it is of the nature of mild, unctuous oils that are not aromatic, and not volatile, and are obtained from vegetables by expreſſion.

It ſeems probable, that the acidifying principle, or vital air, and not an actual acid, may be the leading cauſe of the ſolidity, or low fuſibility of wax. Wax is very uſeful, eſpecially as a better material than any other, for candles.

Wax may be deprived of its natural yellow diſagreeable colour, and be perfectly whitened by expoſure to the united action of air and water, by which method the colour of many ſubſtances may be deſtroyed.

The art of bleaching wax conſiſts in increaſing its ſurface; for which purpoſe it muſt be melted with a degree of heat not ſufficient to alter its quality, in a cauldron ſo diſpoſed, that the melted wax may flow gradually through a pipe at the bottom of the cauldron into a large tub filled with water, in which is fitted a large wooden cylinder, that turns continually round its axis, and upon which the melted wax falls. As the ſurface of this cylinder is always moiſtened with cold water, the wax falling upon it does not adhere to it, but quickly becomes ſolid and flat, and acquires the form of ribbands. The continual rotation of the cylinder carries off theſe ribbands as faſt as they are formed, and diſtributes them through the tub. When all the wax that is to be whitened is thus formed, it is put upon large frames covered with linen cloth, which are ſupported about a foot and a half above the ground, in a ſituation expoſed to the air, the dew, and the ſun. The thickneſs of the ſeveral ribbands thus placed upon the frames, ought not to exceed an inch and a half, and they ought to be moved from time to time, that they may all be equally expoſed to the action of the air. If the weather be favourable, the colour will be changed in the ſpace of ſome days. It is then to be remelted and formed into ribbands, and expoſed to the action of the air as before. Theſe operations are to be repeated till the wax be rendered perfectly white, and then it is to be melted into cakes, or formed into candles.

The yellow colour of the wax is evidently deſtroyed by the combined action of the air, of the water, and of the ſun. As the volatile ſulphureous acid has the property of deſtroying ſtill more quickly almoſt all the colours of vegetables, Macquer ſuppoſed that this bleaching might be ſhortened by expoſing ribbands of yellow wax to the vapour of ſulphur, as is practiſed for wool and ſilk.

His annotator obſerves, that this operation of bleaching wax can be performed well in fine weather only, as it depends chiefly on the action of the ſun. This circumſtance being attended with much inconvenience to the manufacturers, the diſcovery of a method of whitening wax, independently of the ſeaſons, would be very uſeful, and has been recommended to the attention of chemiſts by ſome œconomical ſocieties. With a view to diſcover ſuch a method, Mr. Beckman has made experiments, an account of which is publiſhed in the 5th volume of the Novi Commentarii Societatis Regiæ Scientiarum Gottingenſis. According to theſe experiments, thin pieces of yellow wax were whitened and hardened by being digeſted and boiled in diluted and undiluted nitrous acid in a few hours. But the wax thus whitened being melted by means of boiling water, was obſerved to acquire a yellow colour, leſs intenſe, however, than it was before it had been treated with the mineral acids. The marine and vitriolic acids were leſs effectual than the nitrous. He expoſed wax to the flames of burning ſulphur, but without ſucceſs. Yellow wax being melted in vinegar was rendered of a gray colour. The oil of tartar whitened wax, but leſs effectually than acids had done; and this wax being waſhed in water, and afterwards digeſted in nitrous acid, was rendered ſtill more white; but upon melting it in water a yellowiſh tinge returned. He liquefied wax in ſolutions of nitre and alum, but without any good effect. Spirit of wine, which is recommended by Boyle for this purpoſe, did indeed whiten the wax, but changed it to a butyraceous ſubſtance, ſo frothy that its bulk was increaſed thirty times. Reflecting that tartar is purified from its oily particles by means of a calcareous earth, he tried the effects of a kind of fuller's earth, which he threw upon wax liquefied in water, and he agitated the mixture. This method rendered wax of a grayiſh colour, and is therefore recommended by him as preparatory to bleaching, the time neceſſary for which, he thinks, may be thus greatly ſhortened.

Every kind of wax is not equally capable of being whitened, the colour of ſome adhering ſo ſtrongly, that it cannot be effaced. Such is the wax that comes from countries in which vines grow. This obſervation Macquer received from Mr. Trudon, proprietor of the manufactory of wax at Antoni, near Paris.

Wax is employed for many purpoſes in ſeveral arts. It is alſo uſed in medicine as a ſoftening, emollient, and relaxing remedy: but it is only uſed externally, mixed with other ſubſtances. It is an ingredient in many pomatums, cerates, ointments, and plaiſters, to moſt of which it gives their due conſiſtence.

The following obſervations and experiments by Dr. Pearſon on a wax-like ſubſtance, reſembling the Pé-la of the Chineſe, collected at Madras by Dr. Anderſon, and called by him White Lac, are extracted from the Philoſophical Tranſactions for 1794. I have retained the words of the new Nomenclature as in the original.

Neſts of inſects reſembling ſmall cowry ſhells were brought to Dr. Anderſon, from the woods, by the natives, who eat them with avidity. Theſe ſuppoſed neſts he ſhortly afterwards diſcovered to be the coverings of the females of an undeſcribed ſpecies of coccus; and having noticed, in the Abbé Groſier's Account of China, that the Chineſe collect a kind of wax, much eſteemed by them, under the name of Pé-la, from a coccus depoſited for the purpoſe of breeding on certain ſhrubs, and managed exactly in the ſame manner as the Mexicans manage the cochineal inſect, he followed the ſame proceſs with his new inſects, and ſhortly found means to propagate them with great facility on ſeveral of the trees and ſhrubs growing in his neighbourhood.

On examining the ſubſtance, he obſerved in it a very conſiderable reſemblance to bees-wax; and noticed, moreover, that the animal which ſecretes it, provides itſelf, by ſome means or other, with a ſmall quantity of honey, reſembling that produced by our bees. It is alſo believed that the white lac poſſeſſes medicinal qualities.

It muſt be remembered, that all the authors who deſcribe the true cochineal inſect tell us, that the females when nearly perfect are thickly covered with a white down, or meal, which protects them from the ſun and rain, and the attacks of certain inſects who are their enemies. It is probable that this ſubſtance is of the ſame nature as the pé-la, and that the ſecretion of wax in more or leſs quantity is common to the genus of coccus. It is obſervable, moreover, that the inſect which produces lac, a ſubſtance reſembling wax, provides itſelf alſo with a ſweet fluid reſembling honey. Hence, a ſtriking analogy between theſe three animals is obſervable; and it is far from improbable that future naturaliſts may diſcover them to be ſpecies of the ſame genus; and find the means of making the beautiful red colour produced by the lac inſect as uſeful in dyeing as that of the true cochineal.

A piece of white lac, which weighs from about three to fifteen grains, is probably produced by each inſect. Theſe pieces are of a gray colour, opaque, rough and roundiſh, of about the ſize of a pea, but with a flat ſide, by which they adhere to the bark. In this flat ſide there is a fiſſure which contains a little black matter, the exuviæ of the inſect.

White lac, in its dry ſtate, has a ſaltiſh and bitteriſh taſte, and in the mouth is ſoft and tough. It appears however from Dr. Anderſon's letter, that the taſte of this ſubſtance recently produced is delicious, ſo that it is difficult to prevent the children or other perſons employed to gather it from eating it.

On preſſing a piece of this ſubſtance between the fingers, a watry liquid oozes out, which has a ſlight ſalt taſte; and it is ſaid, that the recently gathered lac is replete with juice.

Although the roundiſh pieces of this ſubſtance yield to preſſure between the fingers, they may be broken, and then appear to be perfectly white within, and of an uniform ſmooth texture. White lac has no ſmell, unleſs it be preſſed or rubbed till it is ſoft, and then it emits a peculiar odour.

The lac which had been ſtrained through muſlin was of a brown colour throughout its whole ſubſtance, was brittle, hard, and had a bitteriſh taſte, without any ſaltneſs, for its watry liquid had been ſeparated by melting.

The pieces of lac gathered from the tree are as light, or lighter than bees-wax; but after being melted and purified by ſtraining, it ſinks in water, and therefore is ſpecifically heavier than bees-wax generally is.

White lac melts in water of the temperature of 145° of Fahrenheit's thermometer. In boiling water it readily melted, and the black exuviæ were thus ſeparated from the lac.

Two thouſand grains of white lac were expoſed in ſuch a degree of caloric as was juſt ſufficient to melt them; as they grew ſoft and fluid, a pretty large quantity of reddiſh watry fluid, namely 550 grains, which emitted the ſmell of newly baked bread, oozed out. This liquid was poured off for examination, and the lac was ſtrained through fine cloth repeatedly, till it left no exuviæ or other extraneous matter on the filter.

The quantity of purified lac thus obtained was 1220 grains. It was yellow like bees wax; hard and brittle as roſin. It had no bitteriſh, or ſcarcely any other taſte. It melted in alcohol, and alſo in water, of the temperature of between 145° and 146°.

Purified white lac adheres very firmly to wood, tin, paper, &c. ſo that it is an excellent cement on many occaſions.

The following experiments were made to diſcover ſome of the affinities and combinations of white lac.

1. Yellow purified lac above mentioned was ſpread thin upon a plate of glaſs, and expoſed to the rays of the ſun during the whole of the month of July, 1793, but it was not by this means rendered at all leſs yellow.

2. A piece of white lac, on boiling in water with powdered charcoal, was abſorbed, and diſappeared.

3. Purified lac was digeſted in various proportions of ley of pure pot-aſh, in different temperatures, but an uniform or ſoap-like maſs could not be formed. The mixture emitted the ſmell of palm oil. The lac turned to a brown colour, and had the appearance of a coagulated maſs, in the liquid as well as dry ſtate. The liquid filtered from theſe ſolutions had a ſweetiſh and bitteriſh taſte. Upon the addition of vinegar, it became very turbid and roſe-coloured; and by ſtanding it let fall a copious ſediment, which being dried was found to be white lac only rendered more brittle.

4. Ammoniac, or cauſtic volatile alkali, ſeemed to combine with the white lac. The compound was a tolerably uniform brown ſoapy ſubſtance. It taſted ſweet, and had ſtill a weak ſmell of ammoniac. It rendered water milky, and this ſolution became curdy on adding to it acetous acid.

5. Candles of different thickneſſes were made of purified white lac above mentioned, with cotton wicks of different thickneſſes; and candles were alſo made of white lac which had been diſſolved in ſulphuric æther, and in volatile oil of turpentine. They all burned more rapidly, but Dr. Pearſon is of opinion that they emitted a leſs quantity of light, than wax candles of the ſame ſize. The candles made of white lac alſo ſmoked, and produced a roſinous ſmell.

White lac burned in oxygen gas without affording any ſmoke, and with a beautifully bright flame.

A ſmall piece of purified white lac, in a platina ſpoon, was expoſed to the apex of the violet blue coloured flame of a candle, by means of the blow-pipe; a ſmall quantity of black matter remained in the ſpoon, which could not be carried off by a long continued application of the flame; but after keeping the ſpoon red-hot in the fire for ten minutes, nothing but a very ſmall quantity of gray aſh was left.

6. From purified white lac nothing could be extracted by water; nor from the lac in its impure ſtate, except a bitteriſh mucilage.

7. White lac turned to a black coloured ſubſtance by boiling it in concentrated ſulphuric acid. The mixture was then diluted with water; and by means of the filter a carbonaceous matter was ſeparated, which on being made red-hot burned in the air without flaming. The filtered liquor, upon evaporation to dryneſs, afforded no alkaline or other reſidue.

8. Glaſs covered with a thin coat of white lac was kept immerſed in oxygenated muriatic acid gas, and alſo in water ſaturated with this gas, for ſeveral months, without producing any apparent change on the colour of the lac, or in its other properties.

9. On about 100 grains of white lac were poured 400 grains of concentrated nitrous acid. In a few minutes time the acid became of a deep orange colour, and on making it hot, nitrous gas was diſcharged, with an ebullition of the liquid. A freſh diſcharge of nitrous gas took place on adding more nitrous acid. On applying caloric, to make the acid boil and to melt the lac, this ſubſtance was totally diſſolved; but on ſtanding to cool, it ſeemed to be wholly ſeparated from the acid, and was rendered white. On diluting with water the acid from which the lac had ſeparated itſelf, a very ſlight curdy precipitation took place; and the ſame appearance followed on adding ley of pot-aſh. On evaporating this acid to dryneſs, a very ſmall reſidue of lac was obtained. Dr. Pearſon diſſolved a little of this ſubſtance, by boiling it in concentrated nitrous acid, and poured the ſolution, while hot, into water; upon which a very copious precipitation inſtantly took place, of the lac rendered quite white.

10. One hundred grains of the ſubſtance under examination were totally diſſolved, and very readily, in 500 grains of volatile oil of turpentine. While this ſolution was hot it was clear, but on cooling it grew opaque and white. On evaporation the whole of the lac was recovered.

11. Fifty grains of white lac readily diſſolved in 500 grains meaſure of ſulphuric æther, in the temperature of 80°. This ſolution was not unctuous, or reſinous; the lower part of it was like an emulſion, and the upper part of it was tranſparent and limpid; but both parts contained the ſubſtance diſſolved. Upon evaporation the lac was recovered in the form of a light white powder, which on melting became a brittle yellow ſolid, as heavy as before ſolution.

12. One hundred grains of white lac being digeſted in 1000 grains meaſure of alcohol, the ſpecific gravity of which was as 835 to 1000, about half of the ſubſtance ſoon diſſolved; and the ſolution when cold was opake, white, and thick, as ſaturated ſolution of ſoap in hot ſpirit of wine appears on cooling. By repeated affuſions of alcohol on the reſidue of theſe 100 grains, all but about 15 grains was diſſolved; and this reſidue did not appear to be different from lac which had not been digeſted in this menſtruum. This ſolution afforded, on evaporation, a light white opake powder, which on being melted was a brittle, yellow, heavy ſolid, as the ſubſtance was before ſolution.

Saturated ſolution of white lac in alcohol ſpread upon paper, cloth, wood, &c. on evaporation left a thin coat of reſinous matter, which was not however bright and ſmooth; and therefore this ſolution did not afford a good varniſh.

Of the experiments which Dr. Pearſon made to decompound white lac by fire, he only particularly relates the following one, becauſe among ſeveral which he made there was no material difference in the reſult.

Eight hundred grains of purified white lac were put into a glaſs retort, to which was affixed an adopter with a large bulb to receive condenſed vapours, and the hydro-pneumatic apparatus to collect elaſtic fluids, or gaſes. Theſe diſtilled over 204 grains of yellow ſtrongly empyreumatic oil of the conſiſtence of butter, 400 grains of thin oil which had the ſmell of tar, near 20 grains of watry liquid containing a little acid, perhaps the pyrotartareous or the ſebacic acid; beſides 307 cubic inches of gas. In the retort there remained 37 grains of carbonaceous matter, which was a pretty hard cinder, the under ſurface of which in contact with the glaſs had ſeemingly undergone a partial fuſion, and the glaſs itſelf to which it adhered appeared to have been a little corroded.

The above diſtilled gas contained no oxygen to the teſt of nitrous gas; but 32 cubic inches of it were abſorbed by milk of lime, and near 86 cubic inches of it were abſorbed by yellow oxyd of lead, or maſſicot, placed in the focus of a lens; during which abſorption lead was reduced, and water compoſed. The remainder of the gas extinguiſhed flame, and was concluded to be nitrogen or azotic gas.

The gas which was obtained by diſtillation was therefore a mixture of carbonic acid, hydrogen and nitrogen gas. This mixture burned like what has been called heavy inflammable air.

The above 37 grains of carbonaceous matter afforded two grains of muriate of ſoda, one grain of carbonate of ſoda, four grains of phoſphate of ſoda. The lixiviated carbonaceous matter being mixed with 300 grains of red oxyd of lead, and expoſed to a due degree of fire, yielded about 60 cubic inches of carbonic acid gas, and a little regulus of lead; but there was a reſidue of carbonaceous matter which could not be burnt away in the fierceſt fire in open veſſels. This reſidue was probably carbon, phoſphoric acid, and ſoda, intimately mixed by fuſion.

From this analyſis, it appears that 100 parts of white lac purified yield,

Butyraceous oil	25½
Thin oil	50
Water containing acid	2½
Carbonaceous matter, containing phoſphoric acid, muriatic acid, and ſoda	4½
Carbonic acid, by eſtimation	4
Hydrogen, by eſtimation	1½
Nitrogen or azote, by eſtimation	10
	98
Deficiency by waſte and error, by eſtimation	2
	100 parts.

When this experiment was made with unpurified white lac, the proportion of water and carbonaceous matter was much greater than in the preceding experiment. On account alſo of the water, it was extremely difficult to prevent the ſubſtance boiling over and burſting the veſſels.

Charcoal of wood being mixed with white lac, the oil ſeemed to diſtil over more readily, with leſs water, and was paler coloured oil than in the preceding experiment.

White lac was alſo diſtilled from pot-aſh, without any material difference in the reſult, excepting that the oils which diſtilled over were thicker.

The following experiments were made on the liquid contained in white lac:

(*a*) On preſſing, between the fingers, the pieces of white lac, in the ſtate in which they are taken from the tree or ſhrub (although they are apparently quite dry and brittle, and have been kept ſeveral years), a watery liquid oozes out; by which paper ſtained with turnſole is inſtantly turned to a red colour.

(*b*) The 550 grains of reddiſh watry liquid above mentioned to have been ſeparated from 2000 grains of white lac, were filtrated through paper in order to ſeparate mucilage.

(*aa*) This filtrated liquid has a ſlightly ſaltiſh taſte, with bitterneſs, but is not at all ſour.

(*bb*) When made hot, it ſmells preciſely like newly baked hot bread.

(*cc*) On ſtanding it grows ſomewhat turbid, and depoſits a ſmall quantity of ſediment.

(*dd*) Its ſpecific gravity in the temperature of 60° was to diſtilled water as 1025 to 1000.

(*ee*) A little of this liquid having been evaporated till it grew very turbid, on ſtanding afforded ſmall needle-like cryſtals in mucilaginous matter.

(*c*) About 250 grains of the liquid (*b*) were poured into a retort which held one ounce meaſure, to which was joined a receiver containing two ſhreds of paper, one ſtained with turnſole, and the other had been dipped in ſolution of ſulphate of iron. As the liquor grew warm, mucilage-like clouds appeared, but when it grew hot they diſappeared; and about the temperature of 200° it diſtilled over very faſt. On diſtillation to nearly dryneſs, a ſmall quantity of extractive matter remained. The diſtilled liquor while hot ſmelt like newly baked bread, and was perfectly tranſparent and yellowiſh. The paper ſtained with turnſole was not reddened; nor was that which had been immerſed in ſolution of ſulphate of iron turned to a blue colour, upon moiſtening it with ley of pot-aſh.

(*d*) The flame of a candle being applied by means of a blow-pipe to the extractive matter (*c*), the whole of it was burnt away, except what produced a black mark upon the ſpoon; in which no trace of alkali was detected by paper ſtained with turmeric.

(*e*) About a hundred grains of the yellowiſh tranſparent liquid (*c*) being evaporated till it grew turbid, after being ſet by for a night, afforded acicular cryſtals; which under a lens appeared in a group, not unlike the umbel of parſley. The whole of theſe cryſtals could not, probably, have weighed a quarter of a grain. They taſted only bitteriſh.

(*f*) One hundred grains of the yellowiſh tranſparent liquid (*c*) being evaporated, in a very low temperature, to dryneſs, a blackiſh matter was left behind, which did not entirely diſappear on heating the ſpoon containing it very hot in the naked fire; but on heating oxalic acid to a much leſs degree, it evaporated, and left not a trace behind.

(*g*) Carbonate of lime (chalk) readily diſſolved, with effervеſcence, in the liquid (*c*). The ſolution taſted bitteriſh, did not turn paper ſtained with turnſole to a red colour, and a copious precipitation enſued on adding to it carbonate of potaſh (mild vegetable alkali). A little of this ſolution of lime, and alſo of alkali, being evaporated to dryneſs, and the reſidue being made red-hot, nothing remained but carbonate of lime, and carbonate of pot-aſh.

(*h*) The above diſtilled liquid (*c*) did not render nitrate of lime turbid; but

(*i*) It produced turbidneſs in nitrate and muriate of baryt.

(*k*) To 500 grains of the reddiſh coloured liquid obtained by melting white lac, Dr. Pearſon added ley of carbonate of ſoda, till the effervеſcence ceaſed, and the mixture neither reddened paper ſtained with turnſole, nor turned paper ſtained with turmeric to a brown colour. The quantity of dry carbonate of ſoda uſed in the ley was three grains. A quantity of mucilaginous matter, with a little carbonate of lime, was precipitated during this combination. The ſaturated ſolution being filtrated and evaporated to a due degree, it afforded, on ſtanding, deliqueſcent cryſtals.

(*l*) A little of the cryſtallized ſalt (*k*) by expoſure to fire left only a reſidue of carbonate of ſoda.

(*m*) The reddiſh liquid obtained by melting the white lac being filtrated, the following precipitants were added; namely,

1. Lime-water, which produced a light purple, turbid appearance, and on ſtanding, there were juſt perceivable clouds.

2. Sulphurat of lime (calcareous liver of ſulphur) occaſioned a white precipitation; but Dr. Pearſon could not perceive the ſmell of ſulphurized hydrogen gaz (hepatic air).

3. Alcohol of gall nut (tincture of gall nut) induced a grey precipitation.

5. Sulphate of iron (green vitriol) produced a purpliſh colour, but no precipitation; nor did any precipitation take place on adding to this mixture, firſt a little vinegar, and then a little pot-aſh.

5. Acetite of lead (ſugar of lead) occaſioned a reddiſh precipitation, which rediſſolved on adding a little nitrous acid.

6. Nitrate of mercury (ſolution of mercury in nitrous acid) produced a whitiſh turbid liquor.

7. Oxalic acid produced immediately a precipitation of white acicular cryſtals.

8. Tartrite of pot-aſh (ſoluble tartar) being added, a precipitation took place which much reſembled that which takes place on adding tartareous acid to tartrite of pot-aſh; but the precipitated matter by the liquid from the white lac did not re-diſſolve on adding pot-aſh.

With reſpect to the nature of the liquid contained in white lac, our author judges it to belong to the genus of acids, becauſe it changes turnſole to a red coloured ſubſtance, and neutralizes fixed alkali and lime (*g*) (*k*).

This acid liquor is moſt probably ſecreted at the ſame time with the white lac; and therefore the white lac coccus, like the ant, and ſome other inſects, has organs for ſecreting an acid.

As this acid is deſtructible by fire (*f*) (*g*) (*l*), and as it affords carbon (*f*), it muſt be referred to the animal or vegetable acids.

From the precipitation of tartrite of pot-aſh (*m*, 8) reſembling tartar, this acid might be ſuppoſed to be the tartareous; but as this precipitate is not again diſſolved on adding pot aſh; as it has no ſour taſte; as it evaporates in 200° of caloric (*b*); as the combination with lime is readily ſoluble in water, and decompoſed by pot-aſh (*g*) (*m*, 1); and as the combination with ſoda is a deliqueſcent ſalt (*k*), this acid cannot be conſidered to be tartareous. Nor does this liquid appear, from the above experiments, to be any one of the other known vegetable or animal acids. The other properties, ſhewn by the experiments, except the precipitation of tartrite of pot-aſh, and the peculiar ſmell above mentioned, are either thoſe common to every ſpecies of acid, or are poſſeſſed by ſeveral of them. For although this acid poſſeſſes ſeveral properties common to all acids, and ſome properties which belong to a few ſpecies only, there is not any one of the already known acids that has the ſmell, when heated, above mentioned; that precipitates tartrite of pot-aſh, but does not ſerve to compoſe acidulous tartrite of pot-aſh; that, beſides, having theſe properties, is vapour in the temperature of 200° without decompoſition, has not a ſour but a bitteriſh taſte, and forms a ſoluble compound with lime, which is decompoſable by pot-aſh.

The precipitation by oxalic acid, it is probable, was occaſioned by a ſmall quantity of lime which the undiſtilled liquid of white lac contains.

Dr. Pearſon obſerves moreover, that he does not refer to the other phenomena in the experiments, becauſe they are produced by acids in general.

Whether the above liquid from white lac be a new acid, or one of the acids already known, but diſguiſed by mixture or union with other bodies, he leaves to the deciſion of future experiments, and to the judgment of learned chemiſts.

Dr. Pearſon makes the following remarks and concluſions from the preceding obſervations and experiments;

1. White lac being unctuous when in the fluid ſtate; having little or no ſmell and taſte, unleſs heated; being inſoluble in water; being inflammable in oxygen gas; and decompounded by fire alone, in cloſe veſſels, before evaporation, it ſeems to belong to the genus of fat, or fixed oils: but it differs from them, and reſembles the volatile oils and reſins, in being brittle and ſemi-tranſparent; in being ſoluble in alcohol; in compoſing an imperfect ſoap with fixed alkalis; in diſſolving readily in ſulphuric æther.

2. As bees wax and white lac ſeemed to be alike in many properties, Dr. Pearſon extended the compariſon by ſome experiments on bees wax.

Bees wax when firſt ſecreted is always white, and it is often white when made into the comb. It remains white after being melted.

White lac becomes yellow, on purification by melting and ſtraining.

Bees wax has a peculiar ſmell when cold. White lac has a ſmell only when made hot, and it is a different one from that of bees wax.

Bees wax is leſs brittle and hard than white lac. The former is generally ſpecifically lighter than the latter; for bees wax often floated upon cold water, but purified lac fell to the bottom.

Bees wax melts at about 142°; and therefore in a few degrees leſs caloric than white lac.

Bees wax does not adhere ſo firmly to different bodies as white lac.

Yellow bees wax can be rendered white by expoſure to the ſolar light, or by oxygenated muriatic acid, but this lac could not be bleached.

Bees wax formed a ſoap-like maſs by union with pot-aſh, which was ſoluble like common ſoap in water, but this lac afforded an imperfect ſoap.

It is well known that bees wax burns without affording almoſt any ſmoke or ſmell, and produces a ſteady light. Dr. Pearſon did not find that white lac, united with oil of olive, formed a wax little inferior to bees wax, which is ſaid to be the caſe with the pé-la of the Chineſe. By this union he made white lac whiter and as ſoft as bees wax; but it ſtill afforded ſmoke, a reſinous ſmell, and an unſteady light, as before.

Water extracted nothing from pure bees wax.

Nitrous acid, in the cold, only rendered it white; but, on boiling, the lac wholly diſſolved; and like the white lac, on cooling, it ſeparated, and was rendered white.

Oil of turpentine, and

Sulphuric æther formed compounds with bees wax ſimilar to thoſe with white lac. The ſolution of bees wax in ſulphuric æther, on evaporation left a white powdery ſubſtance, which on melting was found to be common yellow wax.

Alcohol, the ſpecific gravity of which to water was as 835 to 1000, diſſolved bees wax with much more difficulty, and in much ſmaller proportion, than white lac. By digeſtion in this menſtruum, at the temperature of 130° to 140°, it appeared that bees wax was totally ſoluble; but the ſame wax by repeated digeſtions became more and more difficultly ſoluble; and yet it did not appear that the laſt portion of wax was different in its other properties from wax which had not been digeſted.

On evaporation of this ſolution to dryneſs, a white ſubſtance in a powdery form remained, which being melted was yellow wax.

Bees wax, on decompoſition by fire, in cloſe veſſels, with the hydro-pneumatic apparatus affixed, yielded reſembling or nearly ſimilar ſubſtances to thoſe obtained on the analyſis of white lac by fire ; for 1800 grains of bees wax gave 1200 grains of white butyraceous oil, with a little thin brown oil, and a very ſmall quantity of water and acid ; and a very large quantity of hydrogen and carbonic acid gas, with which was probably mixed nitrogen gas ; but Dr. Pearſon was prevented by an accident from determining the preſence of this laſt gas. In the retort there remained only about ten grains of carbonaceous matter The ſmell of the empyreumatic oils was very different from thoſe of white lac.

3. White lac appears to have the ſame kinds of affinity as bees wax ; but many of their combinations are ſo very different in the two caſes as to determine white lac and bees wax to be different ſpecies of ſubſtances, although they agree with one another in more properties than they do with any other known bodies. As to the pé-la of the Chineſe, we cannot judge of it unleſs a more particular account had been given of its qualities.

4. White lac and bees wax appear to be homogeneous ſubſtances, and to conſiſt of the ſame kind of conſtituent parts, but the proportion of theſe parts is very different in the two ſubſtances; and hence the difference in the properties of bees wax and white lac. Dr. Pearſon conſiders the phoſphorate of lime, the ſoda and muriate of ſoda, as extraneous to the compoſition of lac. The different compoſition of the two ſubſtances may, he thinks, enable us to explain in a probable manner the different action of other bodies upon them. For inſtance, as it appears that a much greater proportion of carbon enters into the compoſition of white lac than bees wax, the quantity of oxygen gas in atmoſpheric air, applied under the uſual circumſtances of combuſtion, is not ſufficient to combine with the whole of the carbon, and other components of a given part of white lac, wherefore a portion of carbon remains uncombined, in the form of ſoot, or a ſublimate ; but when oxygen gas is applied, the whole of the carbon is combined with it, and of courſe no ſmoke appears.

The ſmaller proportion of carbon in bees wax than white lac, affords a probable reaſon why there is leſs ſmoke during the combuſtion of bees wax than white lac.

It appears reaſonable to conclude, that white lac might be made to ſerve for illumination and combuſtion as well as bees wax, either by diminiſhing the proportion of carbon, or by increaſing the proportion of the other components.

WEIGHTS. For a table of weights ſee BALANCE. It would certainly be very advantageous for ſcience, if all chemical operations were made with weights decimally divided. For though the abſolute quantities uſed by philoſophers in different nations would not by this means be known, yet the proportional reſults would be every where the ſame. As the writings of the French chemiſts frequently convey accounts of weight in pounds, marks, gros, or grains, it may be uſeful in this place to obſerve, that

The Paris pound contains 2 marks, and is to the Engliſh troy pound as 21 to 16. It is equal to 7560 troy grains.

The Paris mark contains 8 Paris ounces.

The Paris ounce contains 8 Paris drams or gros, and is equal to $472\frac{1}{2}$ troy grains.

The Paris dram or gros contains 3 Paris ſcruples, or deniers, and is equal to 72 Paris grains, or to $59\frac{1}{2}$ troy grains.

The Paris ſcruple or denier contains 24 Paris grains, and is equal to $19\frac{33}{48}$ troy grains.

The Paris grain is the $\frac{1}{9216}$th part of a Paris pound, and is to the troy grain as 7560 to 9216.

WELD, or WOALD (reſeda luteola, Lin.), is a plant very common in the environs of Paris, in moſt of the French provinces, and in a great part of the reſt of Europe. It puſhes out long narrow leaves, of a lively green: from the midſt of theſe leaves the ſtalk riſes to the height of three or four feet, frequently branchy, and furniſhed with leaves, narrow like the radical ones, but ſhorter as they approach the flowers, which are diſpoſed in long ſpikes. The whole of the plant is uſed for dyeing yellow.

Two ſorts of weld are diſtinguiſhed. The baſtard, or wild, which grows naturally in the fields; and the cultivated, the ſtalks of which are ſmaller, and not ſo high. For dyeing, the latter is preferred, it abounding more in colouring matter. The more ſlender the ſtalk, the more it is valued.

When the weld is ripe, it is pulled, dried, and made into bundles, in which ſtate it is uſed.

When the decoction of weld is very ſtrong, it has a yellow colour inclining to brown: if it be greatly diluted with water, its yellow, which is more or leſs pale, inclines a little to green.

If a little alkali be added to this decoction, its colour grows deeper, and after a certain time, a little aſh-coloured precipitate falls down, which is not ſoluble in alkalis.

Acids in general render its colour paler, and occaſion a little precipitate, which will diſſolve in alkalis, giving them a yellow colour inclining to brown.

Alum forms with it a yellowiſh precipitate, and the liquor retains a fine lemon colour. If a ſolution of alkali be poured into this liquor, a whitiſh yellow precipitate, ſoluble in alkalis, is thrown down, but the liquor ſtill remains coloured.

Solution of common ſalt, or of ſal ammoniac, renders the liquor turbid, and its colour at firſt a little deeper; by degrees a deep yellow precipitate forms, and the ſupernatant liquor retains a pale yellow colour, a little inclining to green.

Solution of tin produces a copious bright yellow precipitate: the liquor remains a long time turbid, but ſlightly coloured.

Vitriol of iron produces a plentiful dark gray precipitate, and the ſupernatant liquor is browniſh.

Vitriol of copper occaſions a browniſh green precipitate, and the liquor preſerves a pale green colour.

The yellow communicated to wool by weld has little permanency, if the wool be not previouſly prepared by ſome mordant. For this purpoſe alum and tartar are uſed, by means of which that plant gives a very pure yellow, which has the advantage of being permanent.

For the boiling, which is conducted in the common way, Hellot directs four ounces of alum to every pound of wool, and only one ounce of tartar: many dyers, however, uſe half as much tartar as alum. Tartar renders the colour paler, but more lively.

For the welding, that is for the dyeing with weld, the plant is boiled in a freſh bath, incloſing it in a bag of thin linen, and keeping it from riſing to the top by means of a heavy wooden croſs. Some dyers boil it till it ſinks to the bottom of the copper, and then let a croſs down upon it: others, when it is boiled, take it out with a rake and throw it away.

Hellot directs five or ſix pounds of weld for every pound of cloth; but dyers ſeldom uſe ſo much, contenting themſelves with three or four pounds, or even much leſs. Many indeed add to the weld a little quick-lime and aſhes, which favour the extraction of the colouring matter, and heighten its colour, but at the ſame time render it liable to be changed by the action of acids. The quantity of weld, however, ought to be proportionate to the depth of the ſhade to be obtained.

Lighter and brighter ſhades may be obtained by dyeing after deeper ones, adding water at each dipping, and keeping the bath boiling: but light ſhades procured in this way are not ſo lively as when freſh baths are uſed, proportioning the quantity of weld to the depth of the ſhade.

Common ſalt added to the weld bath renders its colour richer and deeper: vitriol of lime, or gypſum, alſo deepens it: but alum renders it paler and more lively; and tartar ſtill paler. Vitriol of iron makes it incline to brown. The ſhades obtained from weld may be modified by ſuch additions, by the proportion of the weld, by the length of the operation, and by the mordants employed in preparing the ſtuff. Thus Scheffer ſays, that by boiling the wool two hours with a fourth its weight of ſolution of tin, and the ſame of tartar, waſhing it and boiling it fifteen minutes with an equal weight of weld, it will take a fine yellow, which, however, will not penetrate its internal texture. Mr. Poerner alſo directs the cloth to be prepared as for dyeing ſcarlet. By theſe means greater brightneſs and permanency are given to the colour, which, *cæteris paribus*, is at the ſame time lighter.

The colour may be modified alſo by paſſing the cloth, when it comes out of the dye, through another bath. Thus, to produce a golden yellow, the cloth, when it comes out of the welding, may be paſſed through a ſlight madder bath; and for a tawny (tannée), through a bath made with a little ſoot.

To dye ſilk plain yellow, in general no other ingredient than weld is uſed. The ſilk ought to be ſcoured in the proportion of twenty pounds of ſoap to the hundred, and afterwards alumed and refreſhed, that is, waſhed after the aluming.

A bath is prepared with two pounds of weld for each pound of ſilk, which after a quarter of an hour's boiling is to be paſſed through a ſieve or cloth into a vat; when it is of ſuch a temperature as the hand can bear, the ſilk is put in, and turned till the colour is become uniform: during this operation the weld is boiled a ſecond time in freſh water; about half of the firſt bath is taken out, and its place ſupplied by a freſh decoction. This freſh bath may be uſed a little hotter than the former; too great a degree of heat however muſt be avoided, that no part of the colour already fixed may be diſſolved; it is to be turned as before, and in the mean time a quantity of cendres gravellées is to be diſſolved in a part of the ſecond decoction; the ſilk is to be taken out of the bath, that more or leſs of this ſolution may be put in, according to the ſhade required. After it has been turned a few times, a hank is wrung with the pin, that it may be ſeen whether the colour be ſufficiently full, and have the proper gold caſt: if it ſhould not, a little more of the alkaline ſolution is added, the effect of which is to give the colour a gold caſt, and to render it deeper. In this way the proceſs is to be continued, until the ſilk has attained the deſired ſhade; the alkaline ſolution may alſo be added along with the ſecond decoction of the weld, always taking care that the bath be not too hot.

If we wiſh to produce yellows with more of a gold or jonquille colour, a quantity of anotta proportioned to the ſhade required muſt be added to the bath along with the alkali.

For the light ſhades of yellow, ſuch as pale lemon or canary-bird colour, the ſilk ought to be ſcoured as for blue, becauſe the ſhades are more beautiful and tranſparent in proportion as the ground on which they are laid is whiter: the ſtrength of the bath is proportioned to the ſhade we wiſh to obtain; and if we intend that the yellow ſhould have a tinge inclining to green, more or leſs of the indigo vat is added, if the ſilk has not been azured. To prevent the ſhades from being too deep, the ſilk may be more ſlightly alumed than uſual.

Scheffer directs that the ſilk ſhould be ſoaked twenty-four hours in a ſolution of tin, made with four parts of nitrous acid, one of common ſalt, and one of tin, and ſaturated with tartar; that it ſhould be waſhed, and boiled half an hour with an equal quantity of weld flowers. He ſays, that a fine ſtraw-colour is thus obtained, which poſſeſſes the advantage of reſiſting the action of acids. By following this proceſs, very little tin can remain in the ſolution, becauſe the acid of tartar precipitates it.

In dyeing cotton yellow, we begin by ſcouring it in a bath prepared with the ley of the aſhes of green wood; it is then waſhed, dried, and alumed with one fourth of its weight of alum; after twenty-four hours it is taken out of the aluming, and dried without being waſhed. A weld bath is then prepared, with the proportion of a pound and a quarter of weld for each pound of cotton; in this the cotton is dyed, by being turned and wrought in it until it has acquired a proper ſhade; it is taken out of this bath to be ſoaked for an hour and a half, in a ſolution of vitriol of copper or blue vitriol, in the proportion of one fourth of the weight of the cotton; it is then thrown, without being waſhed, into a boiling ſolution of white ſoap made with the ſame proportions: after being well ſtirred, it is boiled in it for nearly an hour, then well waſhed and dried. Berthollet.

WHEAT. The firſt part of the preparation of farinaceous ſeeds to be uſed as food, conſiſts in mechanical trituration; after which, by the addition of water, and the ſubſequent action of heat, bread and other well known compounds are formed. Wheat is found by experience to be the moſt nutritive of vegetable matters, and upon chemical examination it proves to poſſeſs more of the gluten, or vegeto-animal matter, than any other ſubſtance of this claſs. Meſſrs. Beccari, an Italian phyſician, and Keſſel Meyer, in Germany, are the firſt chemiſts who attempted to ſeparate the different principles of which farina conſiſts. Meſſrs. Rouelle, Spielman, Malouin, Parmentier, Poulletier de la Salle, and Macquer, have proſecuted theſe reſearches much farther than the above-mentioned naturaliſts. M. Parmentier eſpecially has proſecuted them with very uncommon zeal and induſtry.

In performing this analyſis, a paſte is firſt to be compoſed of the farina with water; the paſte muſt then be kneaded in an earthen veſſel, with water pouring upon it from a cock; the fluid as it falls upon the paſte takes up from it a very fine white powder, by means of which it acquires the colour and conſiſtency of milk; let this proceſs be continued till the water runs off clear. The farina is now found to be naturally ſeparated into three diſtinct ſubſtances—a gray elaſtic matter that ſticks to the hand, and on account of its properties has gained the name of the glutinous or vegeto-animal part; a white powder which falls to the bottom of the water, and is the feculum or ſtarch; and a matter which remains diſſolved in the water, and ſeems to be a ſort of mucilaginous extract. We ſhall proceed to an examination of each of theſe three ſubſtances.

The glutinous part is a tenacious, ductile, elaſtic matter, of a whitiſh gray colour. It may be extended to twenty times its natural length; and it then ſeems as if compoſed of fibres or filaments. When the power by which it was extended ceaſes to act, it returns with elaſtic force towards its primary form. By drawing it out in different directions, it may be rendered ſo thin as to reſemble the membranes of animals. In this ſtate it adheres with conſiderable force to dry bodies; and forms a very tenacious glue, which was uſed by ſome artiſts for the purpoſe of re-uniting pieces of broken porcelain, long before chemiſts had diſcovered the method of obtaining it in large quantities. M. Beccari obſerves, that in the beſt flour the proportion of the glutinous matter is from a fifth to a third part, or even more:—he remarks too, that this proportion varies according to the ſeaſon and the nature of the corn.

The glutinous matter has an agreeable and ſomewhat muſcous ſmell; its taſte is inſipid; it ſwells amazingly when expoſed to a ſtrength of heat ſufficient to dry it quickly. It dries very well by a moderate heat, or even in the dry air. It then becomes ſemi-tranſparent and hard, like a ſtrong glue, and like that ſubſtance breaks with noiſe, and with a ſmooth fracture. If when in this ſtate it be laid on a burning coal, or held over the flame of a taper, it exhibits all the characteriſtics of an animal matter; it crackles, ſwells, becomes liquid, is agitated, and burns in the ſame way as a feather, or a piece of horn, exhaling a ſtrong fetid ſmell. When diſtilled in a retort, it affords, like animal matters, water impregnated with volatile alkali, the ſame alkali in a concrete ſtate, and an empyreumatic oil; the carbonaceous reſidue is very difficult to incinerate, and is found to contain no fixed alkali.

The gluten, when expoſed freſh to a moiſt and hot air, is altered, and actually putrefies in the ſame manner as animal matters. If it ſtill retain a little ſtarch, then the ſtarch, paſſing into the ſtate of acid fermentation, retards and modifies the putrid fermentation of the gluten, and reduces it to a ſtate in which it is much like cheeſe. In this way Rouelle the younger prepared from this gluten a ſpecies of cheeſe, in taſte and ſmell much the ſame with Dutch cheeſe and that of Gruyere.

Water does not at all diſſolve this glutinous matter. When boiled in that fluid, it becomes ſolid, and loſes its tenacity and elaſticity, but neither acquires a taſte nor becomes ſoluble in the ſaliva. It may however be obſerved, that to the water which was uſed in making the paſte the gluten owes its elaſticity and ſolidity. In the farina, this vegeto-animal matter, which is thus ſuſceptible of a ſolid elaſtic form, was in an incoherent and pulverulent ſtate; but when the water is poured upon the farina and mixed with it, thoſe particles which are of a glutinous nature abſorb the fluid, and are by its means ſo cloſely united as to form, in a ſhort time, that ſort of elaſtic ſolid which is known by the name of gluten. Water therefore contributes greatly to the formation of this ſubſtance, which is perhaps to be conſidered as a peculiar compound ſaturated with water, and for that reaſon not capable of abſorbing any more. So true is this, that if it be deprived of its water by deſiccation, it loſes entirely its elaſtic and adheſive powers.

Moſt ſaline ſubſtances act either with more or leſs force on this gluten. The vegetable and mineral alkalis, in a cauſtic and liquid ſtate, diſſolve it with the help of a boiling heat. The ſolution is turbid, and on the addition of acids depoſits gluten, which however is deſtitute of elaſticity.

The mineral acids diſſolve this gluten. The nitrous acid diſſolves it with great activity; and M. Berthollet has obſerved, that this gluten, like animal ſubſtances, emits azotic gas, when expoſed to the action of the nitrous acid. After the emiſſion of this elaſtic fluid, the ſolution affords a great deal of nitrous gas, and takes a yellow colour. By evaporation it affords acid of ſugar in cryſtals. The vitriolic and the muriatic acids form with this ſubſtance brown or violet ſolutions. A ſort of oily matter is ſeparated from theſe ſolutions; and the gluten exiſts in them in a real ſtate of decompoſition. M. Poulletier, who has made many experiments on this matter, has diſcovered, that ammoniacal ſalts may be obtained from theſe combinations diſſolved in water or alcohol, and evaporated in the open air.

Fourcroy remarks, that this ſubſtance in many of its diſtinguiſhing properties bears a great reſemblance to the fibrous part of blood. It is to this gluten the farina of wheat owes its property of forming an adheſive paſte with water, and its readineſs to riſe with leaven. It appears either not to exiſt, or to exiſt only in a very ſmall proportion, in the farina of other vegetable ſubſtances, ſuch as rye, barley, buck wheat, rice, &c. all of which form ſolid, opaque paſtes, ſcarcely ductile and brittle, and which can ſcarce be raiſed when expoſed to the ſame temperature by which paſte of the farina of wheat is raiſed. No other ſubſtance but flour of wheat, therefore, is poſſeſſed of all the qualities neceſſary for making good bread.

Berthollet is of opinion, that this glutinous ſubſtance, like animal matters, contains phoſphoric ſalts, which are the occaſion of its being ſo difficult to incinerate. Rouelle the younger has diſcovered a glutinous ſubſtance, reſembling that of the farina of wheat, in the green fecula of plants, which affords by analyſis mild vegetable alkali, and empyreumatic oil, like the vegeto-animal matter of which we have been ſpeaking.

Starch, or the amylaceous feculum, is the moſt copious part of the farina. This is the ſubſtance which is carried off, and afterwards precipitated from the water with which the paſte is waſhed in order to obtain the pure gluten. This ſubſtance is very fine, feels ſoft, and has no perceptible taſte. Its colour, when it is extracted by the proceſs above deſcribed, is a dirty gray white; but the manufacturers of ſtarch render it exceedingly white, by ſteeping it in an acid water which they call ſour water. It appears from the experiments of M. Poulletier, that the fermentation which takes place in that fluid whitens and purifies the ſtarch, by attenuating and even deſtroying the extractive mucous ſubſtance which is precipitated with it in the firſt waſhing. Starch chemically conſidered is a mucilage of a peculiar nature. This mucilage, which by ſome chemiſts has been miſtaken for an earth, is very different from the gluten. It does not, like the gluten, diffuſe an empyreumatic ſmell when it burns. When diſtilled by naked fire, it affords an acid phlegm of a brown colour, and towards the concluſion of the proceſs a very thick empyreumatic oil. The coaly reſidue is eaſily enough incinerated, and its aſhes are found to contain fixed alkali.

Starch is not ſoluble in cold water; but when boiled in cold water it forms with the fluid a glue, or rather what we call a paſte. This compound when expoſed to damp air loſes by degrees its conſiſtency, ferments, becomes ſour, and is covered over with mouldineſs.

The nitrous acid affords acid of ſugar when diſtilled from this feculum.

As ſtarch forms the greateſt part of flour, there can be no doubt of its being the principal alimentary ſubſtance contained both in flour and in bread.

By evaporating the clear water that had been uſed in waſhing the paſte, and had depoſited the ſtarch, M. Poulletier obtained a viſcous adheſive matter, of a brown yellow colour, the taſte of which was faintly ſaccharine. This ſubſtance, to which he gave the name of mucoſo-ſaccharine, diſplayed, in combuſtion and diſtillation, the ſame phenomena as ſugar. By it, the acid fermentation is produced in the water which ſwims over ſtarch; for, as Macquer has obſerved, ſtarch is not at all ſoluble in cold water. The mucoſo-ſaccharine matter exiſts in the farina of wheat only in a very ſmall proportion. It may poſſibly be more copious in the farina of ſome other vegetable ſubſtances.

However ſmall the proportion of this ſubſtance in the farina of wheat, yet there can be no doubt of its acting a peculiar part in the fermentation which takes place in paſte and cauſes it to riſe. See BREAD.

WHETSTONE. A general term among artiſts and manufacturers for ſuch ſtones as are uſed to ſharpen tools. I do not know that it is peculiarly appropriated either to Turkey-ſtone, hone, oil-ſtone, or the poliſhing gray argillaceous ſtone, all which are very different in their qualities from each other.

WHEY. The fluid part of milk which remains after the curd has been ſeparated. See MILK. It contains a ſaccharine matter, ſome butter, and a ſmall portion of cheeſe,

WHITE COPPER. See TUTENAG.

WHITE SPANISH, AND WHITE LEAD. See CERUSE.

WHITING. Chalk cleared of its groſſer impurities, then ground in a mill, and made up into ſmall loaves, is ſold under the name of whiting.

WILLOW. The leaves of the willow are mentioned by Scheffer, as proper for giving a fine yellow colour to wool, ſilk, and thread. Bergman aſſerts, that the leaves of the ſweet willow (laurier ſaule), ſalix pentandra, ſhould be employed, and that the leaves of the common willow give a colour which is for the moſt part diſcharged by the ſun in a few weeks.

Scheffer directs, that the wool ſhould be left a whole night in a cold ſolution of three ounces of alum and one ounce of tartar to the pound. The boiling is made with leaves gathered about the end of Auguſt or beginning of September, dried in a ſhady but airy place: as much of theſe as is thought proper is boiled for half an hour, and half a dram of white pot-aſh for each pound is added, to render the colour more bright and deep, and the bath is paſſed through the ſieve; it is kept nearly boiling, and the wool left in it until it has taken the deſired colour. He directs the ſame proceſs for ſilk, and for thread, except that the proportion of alum is increaſed an ounce per pound. According to Bergman's account, Mr. Alſtroemer has obſerved, that the colour was rendered richer by ſoaking the thread with ſix ounces of alum, wringing and drying it before being dyed; and that half an ounce of pot-aſh per pound was required for the complete extraction of the colouring matter.

WINE*. Chemiſts give the name of wine in general to all liquors that have become ſpirituous by fermentation. Thus cyder, beer, vinous hydromel, or mead, and other ſimilar liquors, are wines.

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* From Macquer, with alterations.

The principles and theory of the fermentation which produces theſe liquors are eſſentially the ſame. The more general principles we have explained under the article FERMENTATION.

All thoſe nutritive, vegetable, and animal matters, which contain ſugar ready formed, are ſuſceptible of the ſpirituous fermentation. Thus wine may be made of all the juices of plants, the ſap of trees, the infuſions and decoctions of farinaceous vegetables, the milk of frugivorous animals; and laſtly, it may be made of all ripe ſucculent fruits; but all theſe ſubſtances are not equally proper to be changed into a good and generous wine.

As the production of ardent ſpirit is the reſult of the ſpirituous fermentation, that wine may be conſidered as eſſentially the beſt which contains moſt of this ſpirit. But of all ſubſtances ſuſceptible of the ſpirituous fermentation, none is capable of being converted into ſo good wine, as the juice of the grapes of France, or of other countries that are nearly in the ſame latitude, or in the ſame temperature. The grapes of hotter countries, and even thoſe of the ſouthern provinces of France, do indeed furniſh wines that have a more agreeable, that is, more of a ſaccharine taſte; but theſe wines, though they are ſufficiently ſtrong, are not ſo ſpirituous as thoſe of the provinces near the middle of France: at leaſt, from theſe latter wines the beſt vinegar and aqua vitæ are made. As an example, therefore, of ſpirituous fermentation in general, we ſhall deſcribe the method of making wine from the juice of the grapes of France.

This juice when newly expreſſed, and before it has begun to ferment, is called muſt, and in common language ſweet wine. It is turbid, has an agreeable and very ſaccharine taſte. It is very laxative; and when drunk too freely, or by perſons diſpoſed to diarrhœas, it is apt to occaſion theſe diſorders. Its conſiſtence is ſomewhat leſs fluid than that of water, and it becomes almoſt of a pitchy thickneſs when dried.

When the muſt is preſſed from the grapes, and put into a proper veſſel and place, with a temperature between fifty-five and ſixty degrees, very ſenſible effects are produced in it, in a ſhorter or longer time according to the nature of the liquor, and the expoſure of the place. It then ſwells, and is ſo rarefied, that it frequently overflows the veſſel containing it, if this be nearly full. An inteſtine motion is excited among its parts, accompanied with a ſmall hiſſing noiſe and evident ebullition. The bubbles riſe to the ſurface, and at the ſame time is diſengaged a quantity of fixed air of ſuch purity, and ſo ſubtle and dangerous, that it is capable of killing inſtantly men and animals expoſed to it in a place where the air is not renewed. The ſkins, ſtones, and other groſſer matters of the grapes are buoyed up by the particles of diſengaged air that adhere to their ſurface, are variouſly agitated, and are raiſed in form of a ſcum or ſoft and ſpongy cruſt that covers the whole liquor. During the fermentation this cruſt is frequently raiſed, and broken by the air diſengaged from the liquor which forces its way through it; afterwards the cruſt ſubſides, and becomes entire as before.

Theſe effects continue while the fermentation is briſk, and at laſt gradually ceaſe: then the cruſt, being no longer ſupported, falls in pieces to the bottom of the liquor. At this time, if we would have a ſtrong and generous wine, all ſenſible fermentation muſt be ſtopped. This is done by putting the wine into cloſe veſſels, and carrying theſe into a cellar or other cool place.

After this firſt operation, an interval of repoſe takes place, as is indicated by the ceſſation of the ſenſible effects of the ſpirituous fermentation; and thus enables us to preſerve a liquor no leſs agreeable in its taſte, than uſeful for its reviving and nutritive qualities when drunk moderately.

If we examine the wine produced by this firſt fermentation, we ſhall find that it differs entirely and eſſentially from the juice of grapes before fermentation. Its ſweet and ſaccharine taſte is changed into one that is very different, though ſtill agreeable, and ſomewhat ſpirituous and piquant. It has not the laxative quality of muſt, but affects the head, and occaſions, as is well known, drunkenneſs. Laſtly, if it be diſtilled, it yields, inſtead of the inſipid water obtained from muſt by diſtillation with the heat of boiling water, a volatile, ſpirituous, and inflammable liquor called ſpirit of wine, or ardent ſpirit. This ſpirit is conſequently a new being, produced by the kind of fermentation called the vinous or ſpirituous. See Spirit (Ardent.)

When any liquor undergoes the ſpirituous fermentation, all its parts ſeem not to ferment at the ſame time, otherwiſe the fermentation would probably be very quickly completed, and the appearances would be much more ſtriking: hence, in a liquor much diſpoſed to fermentation, this motion is more quick and ſimultaneous than in another liquor leſs diſpoſed. Experience has ſhewn, that a wine, the fermentation of which is very ſlow and tedious, is never good or very ſpirituous; and therefore, when the weather is too cold, the fermentation is uſually accelerated by heating the place in which the wine is made. A propoſal which Macquer thinks is a good one, has been made by a perſon very intelligent in economical affairs, to apply a greater than the uſual heat to accelerate the fermentation of the wine, in thoſe years in which grapes have not been ſufficiently ripened, and when the juice is not ſufficiently diſpoſed to fermentation.

A too haſty and violent fermentation is perhaps alſo hurtful, from the diſſipation and loſs of ſome of the ſpirit: but of this we are not certain. However, we may diſtinguiſh in the ordinary method of making wines of grapes, two periods in the fermentation, the firſt of which laſts during the appearance of the ſenſible effects above mentioned, in which the greateſt number of fermentable particles do ferment. After this firſt effort of fermentation, theſe effects ſenſibly diminiſh, and ought to be ſtopped for reaſons hereafter to be mentioned. The fermentative motion of the liquors then ceaſes. The heterogeneous parts that were ſuſpended in the wines by this motion, and which render it muddy, are ſeparated, and form a ſediment called the lees; after which the wine becomes clear: but although the operation be then conſidered as finiſhed, and the fermentation apparently ceaſes, it does not really ceaſe; and it ought to be continued in ſome degree, if we would have good wine. In this new wine a part of the liquor probably remains that has not fermented, and which does afterwards ferment, but ſo very ſlowly, that none of the ſenſible effects produced in the firſt fermentation are here perceived. The fermentation therefore ſtill continues in the wine, during a longer or ſhorter time, although in an imperceptible manner; and this is the ſecond period of the ſpirituous fermentation, which may be called the imperceptible fermentation. We may eaſily perceive that the effect of this imperceptible fermentation is the gradual increaſe of the quantity of ſpirit in wine. It has alſo another effect no leſs advantageous, namely, the ſeparation of the acid ſalt called tartar from the wine. This matter is therefore a ſecond ſediment that is formed in the wine, and which adheres to the ſides of the containing veſſels. As the taſte of tartar is harſh and diſagreeable, it is evident that the wine, which by means of the inſenſible fermentation has acquired more ſpirit, and has diſengaged itſelf of the greateſt part of its tartar, ought to be much better and more agreeable; and for this reaſon chiefly, old wine is univerſally preferable to new wine.

But inſenſible fermentation can only ripen and meliorate the wine, if the ſenſible fermentation has regularly proceeded, and has been ſtopped in due time. We know certainly, that if a ſufficient time has not been allowed for the firſt period of the fermentation, the unfermented matter that remains, being in too large a quantity, will then ferment in the bottles, or cloſe veſſels in which the wine is put, and will occaſion effects ſo much more ſenſible, as the firſt fermentation ſhall have been ſooner interrupted: hence theſe wines are always turbid, emit bubbles, and ſometimes break the bottles, from the large quantity of air diſengaged during the fermentation. We have an inſtance of theſe effects in the wine of Champagne, and in others of the ſame kind. The ſenſible fermentation of theſe wines is interrupted, or rather ſuppreſſed, that they may have this ſparkling quality. It is well known that theſe wines make the corks fly out of the bottles, that they ſparkle and froth when they are poured into glaſſes, and laſtly, that they have a taſte much more lively and more piquant than wines that do not ſparkle; but this ſparkling quality, and all the effects depending on it, are only cauſed by a conſiderable quantity of air which is diſengaged during the confined fermentation which the wine has undergone in cloſe veſſels. This air not having an opportunity of eſcaping, and of being diſſipated as faſt as it is diſengaged, and being interpoſed betwixt all the parts of the wine, combines in ſome meaſure with them, and adheres in the ſame manner as it does to certain mineral waters, in which it produces nearly the ſame effects. When this air is entirely diſengaged from theſe wines, they no longer ſparkle, they loſe their piquancy of taſte, become mild, and even almoſt inſipid.

Such are the qualities that wine acquires in time, when its firſt fermentation has not continued ſufficiently long. Theſe qualities are given purpoſely to certain kinds of wine, to indulge taſte or caprice; but ſuch wines are ſuppoſed to be unfit for daily uſe. Wines for daily uſe ought to have undergone ſo completely the ſenſible fermentation, that the ſucceeding fermentation ſhould be inſenſible, or at leaſt exceedingly little perceived. Wine, in which the firſt fermentation has been too far advanced, is liable to worſe inconveniences than that in which the firſt fermentation has been too quickly ſuppreſſed; for every fermentable liquor is from its nature in a continual inteſtine motion, more or leſs ſtrong according to circumſtances, from the firſt inſtant of the ſpirituous fermentation till it is completely putrefied: hence from the time of the completion of the ſpirituous fermentation, or even before, the wine begins to undergo the acid or acetous fermentation. This acid fermentation is very ſlow and inſenſible when the wine is included in very cloſe veſſels, and in a cool place; but it does gradually advance, ſo that in a certain time the wine, inſtead of being meliorated, becomes at laſt ſour. This evil cannot be remedied; becauſe the fermentation may advance, but cannot be reverted. Wine-merchants, therefore, when their wines become ſour, can only conceal or abſorb this acidity by certain ſubſtances, as by alkalis and abſorbent earths. But theſe ſubſtances give to wine a dark greeniſh colour, and a taſte which, though not acid, is ſomewhat diſagreeable. Beſides, calcareous earths accelerate conſiderably the total deſtruction and putrefaction of the wine. Calces of lead, having the property of forming with the acid of vinegar a ſalt of an agreeable ſaccharine taſte, which does not alter the colour of the wine, and which beſides has the advantage of ſtopping fermentation and putrefaction, might be very well employed to remedy the acidity of wine, if lead and all its preparations were not pernicious to health, as they occaſion moſt terrible colics, and even death when taken internally. We cannot believe that any wine-merchant, knowing the evil conſequences of lead, ſhould, for the ſake of gain, employ it for the purpoſe mentioned; but if there be any ſuch perſons, they muſt be conſidered as the poiſoners and murderers of the public.

If wine contains litharge, or any other calx of lead, it may be diſcovered by evaporating ſome pints of it to dryneſs, and melting the reſiduum in a crucible, at the bottom of which a ſmall regulus of lead may be found after the fuſion: but an eaſier and more expeditious proof is by pouring into the wine ſome liquid liver of ſulphur. If the precipitate occaſioned by this addition of the liver be white, or only coloured by the wine, we may know that no lead is contained: but if the precipitate be dark coloured, brown or blackiſh, we may be certain that lead is contained.

The only ſubſtances that cannot abſorb or deſtroy, but cover and render ſupportable the ſharpneſs of wine, without any inconvenience, are ſugar, honey, and other ſaccharine alimentary matters; but they can ſucceed only when the wine is very little acid, and when an exceeding ſmall quantity only of theſe ſubſtances is ſufficient to produce the deſired effect; otherwiſe the wine would have a ſweetiſh, tart, and not agreeable taſte.

From what is here ſaid concerning the aceſcency of wine, we may conclude, that when this accident happens, it cannot by any good method be remedied, and that nothing remains to be done with ſour wine but to ſell it to vinegar makers, as all honeſt wine-merchants do. It may be obſerved, that the firſt ſenſible fermentation having been too far advanced, is not the only cauſe of the acidity of the wine, but that heat alſo is capable of producing the ſame effect. Thus wine which might have been long preſerved in a cool place, very quickly becomes ſour when placed in a bad cellar; and even as the beſt cellars have during the winter a degree of heat much ſuperior to that of the atmoſphere, it would be very proper, when wine diſpoſed to become ſour is to be preſerved, to bring it from the cellar in the beginning of winter, and leave it expoſed to the air during all that ſeaſon.

Wine is alſo liable to various other changes; ſuch as to become ropy and mucilaginous, by the continuance of the fermentative motion: but theſe details would require an expreſs treatiſe.

Wine, and the matters produced from wine, as brandy, ſpirit of wine, vinegar, lees of wine, tartar, are greatly and extenſively uſeful. The lees of wine are employed in the manufacture of hats. Theſe lees, and alſo tartar by incineration, yield a larger quantity than any other vegetable matter of pure fixed alkali.

Wine has been preferred in all times and in all countries to every other alimentary liquor. We may ſay in general, that it is good and ſalutary when taken in ſmall quantities, and that it is pernicious when drunk habitually and in too large quantities. Wine becomes then a true ſlow poiſon, which is ſo much more dangerous, as it is more agreeable. But if we obſerve more particularly the effects of wine, we ſhall perceive very great differences depending on different conſtitutions. Some perſons drink habitually large quantities of pure wine, without any ſenſible inconvenience or diſeaſe, or ſhortening their lives? but, on the contrary, many others do alſo entirely deſtroy their health and ſhorten their lives by an habitual uſe of wine even in ſmall quantity, and mixed with water. Although

though it is always more ſafe and prudent for every perſon to drink little of it habitually, and this moderation is more indiſpenſably neceſſary to thoſe whoſe conſtitutions wine does not ſuit.

As the diſeaſes conſequent upon the too free uſe of wine come gradually and inſenſibly, ſometimes even during many years, ſeveral perſons, eſpecially men otherwiſe very ſober and attentive to health, are every day deceived upon this article, drinking more wine than is ſuitable to their conſtitution, and gradually ruining their health without knowing the cauſe. It is therefore a matter of importance to ſhew the ſigns by which wine may be known to be hurtful. We may know that wine does not ſuit a perſon, when, after drinking moderately of it, his breath acquires a vinous ſmell; when it occaſions ſour belchings and ſlight pains in the head; and when, after drinking it more copiouſly than uſual, it produces ſtupefaction, nauſea, and drunkenneſs, eſpecially when this drunkenneſs is of the moroſe, peeviſh, quarrelſome, and iraſcible kind. Unhappy is that perſon who ſuffers theſe effects from wine, and notwithſtanding perſiſts in the habitual uſe of it. Theſe imprudent perſons never fail of coming to a miſerable death, preceded by languor; and premature, their common age being about fifty years, or a little more. The diſeaſes to which they are moſt ſubject are obſtructions in the liver, in the meſenteric glands, and in other abdominal viſcera, which are almoſt always ſucceeded by an incurable dropſy. Thoſe who digeſt wine well, do not ſuffer, or much leſs ſenſibly, the above-mentioned effects of drinking it. Their drunkenneſs is accompanied with vivacity and joy. Such perſons ſeldom die of the obſtructions and dropſy above mentioned: but wine is nevertheleſs ſo much more dangerous to them, that, as they ſuffer none of the diſagreeable effects, they are more liable to contract the habit of drinking too much. Drinkers of this claſs generally live ſomewhat longer than the former; but their conſtitution generally changes before ſixty years of age; and the inheritance of their old age is either a ſevere gout or palſy, ſtupidity, imbecility, or an accumulation of theſe diſeaſes.

We need not mention that the too frequent uſe of brandy, ratafia, and other ſpirituous liquors, is ſtill more pernicious and fatal than that of wine.

Wine is uſed in medicine as a vehicle in the compoſition of many internal and external remedies. As wine is compoſed of an ardent ſpirit, water, extractive ſaponaceous matter, and acid of tartar, it may be very uſefully employed for the extraction of almoſt all the proximate principles, and conſequently of the medicinal parts, of vegetables. Many extracts are made with wine, which may be conſidered as being more complete than thoſe made with water: but phyſicians who preſcribe theſe extracts ought to remember, that beſides the principles of the vegetables, they alſo contain the extractive part of the wine, that is, all the principles of wine, excepting the ardent ſpirit, which is too volatile to remain in an extract.

As wine when good may be preſerved during a long time, ſeveral medicinal wines preſcribed in diſpenſatories are kept in the ſhops of apothecaries. Such are the aſtringent, antiſcorbutic, febrifugal wines of the Peruvian bark, of wormwood, chalybeate wine, and others. In many caſes, as in ſeveral chronical diſeaſes, where tonic, cordial, fortifying and exciting remedies are indicated, phyſicians prefer the uſe of wine to water, as a vehicle for the infuſion of purgative, aperitive, and other medicinal ſubſtances. See SPIRIT, ARDENT.

WOAD, Iſatis, Glaſtum, is a plant with long green leaves, the lower ones narrow at both ends; thoſe which grow upon the ſtalk broad at bottom, like the head of an arrow. On the tops come forth numerous yellow flowers, which are followed by little flat pods containing the ſeeds. It grows wild in ſome parts of France, and on the coaſts of the Baltic ſea: the wild woad, and that which is cultivated for the uſe of the dyers, appear to be the ſame ſpecies of plant.

The preparation of woad for dyeing, as practiſed in France, is minutely deſcribed by Aſtruc, in his Memoirs for a Natural Hiſtory of Languedoc.—The plant puts forth at firſt five or ſix upright leaves about a foot long and ſix inches broad; when theſe hang downwards, and turn yellow, they are fit for gathering: five crops are gathered in one year. The leaves are carried directly to a mill, much reſembling the oil or tan-mills, and ground into a ſmooth paſte. If this proceſs was deferred for ſome time, they would putrefy, and ſend forth an inſupportable ſtench. The paſte is laid in heaps preſſed cloſe and ſmooth, and the blackiſh cruſt, which forms on the outſide, re-united if it happens to crack: if this was neglected, little worms would be produced in the cracks, and the woad would loſe of its ſtrength. After lying for fifteen days, the heaps are opened, the cruſt rubbed and mixed with the inſide, and the matter formed into oval balls, which are preſſed cloſe and ſolid in wooden moulds. Theſe are dried upon hurdles: in the ſun they turn black on the outſide, in a cloſe place yellowiſh, eſpecially if the weather is rainy. The dealers in this commodity prefer the firſt, though it is ſaid the workmen find no conſiderable difference between the two. The good balls are diſtinguiſhed by their being weighty, of a pretty agreeable ſmell, and, when rubbed, of a violet colour within.—For the uſe of the dyer theſe balls require a farther preparation; they are beaten with wooden mallets, on a brick or ſtone floor, into a groſs powder, which is heaped up in the middle of the room to the height of four feet, a ſpace being left for paſſing round the ſides. The powder moiſtened with water ferments, grows hot, and throws out a thick fetid fume. It is ſhovelled backwards and forwards, and moiſtened every day for twelve days; after which it is ſtirred leſs frequently, without watering, and at length made into a heap for the dyer.

The powder thus prepared gives only browniſh tinctures of different ſhades to water, to rectified ſpirit of wine, to volatile alkaline ſpirits, and to fixed alkaline lixivia; rubbed on paper, it communicates a green ſtain. On diluting the powder with boiling water, and after ſtanding for ſome hours in a cloſe veſſel, adding about one-twentieth its weight of lime newly ſlaked, digeſting in a gentle warmth, and ſtirring the whole together every three or four hours, a new fermentation begins, a blue froth ariſes to the ſurface, and the liquor, though it appears itſelf of a reddiſh colour, dyes woollen of a green, which like the green from indigo changes in the air to a blue. This is one of the niceſt proceſſes in the art of dyeing, and does not well ſucceed in the way of a ſmall experiment.

Aſtruc propoſes the manufacturing of freſh woad leaves in Europe, after the ſame manner as the indigo plant is manufactured in America, and thus preparing from it a blue fecula ſimilar to indigo, which from his own experiments he has found to be practicable. Such a management would doubtleſs be accompanied with ſome advantages, though poſſibly woad ſo prepared might loſe thoſe qualities, which now render it in a large buſineſs preferable on ſome accounts to indigo, as occaſioning greater diſpatch when once the vat is ready, and giving out its colour leſs haſtily, ſo as to be better fitted for dyeing very light ſhades.

Hellot ſuſpects that a like blue fecula is procurable from many other vegetables. Blue and yellow blended together compoſe a green: he ſuppoſes the natural greens of vegetables to be compounded in like manner of thoſe two colours; and that the blue is oftentimes the moſt permanent, ſo as to remain entire after the putrefaction or deſtruction of the yellow. The theory is ſpecious, and perhaps juſt; we know of no other that accounts in any degree for the production of the indigo and woad blue. In the experiments however which Dr. Lewis made, of putrefying different herbs in water, the blue and the yellow colour, if the green was really compoſed of theſe, were both deſtroyed together, no appearance being obſerved either of one or the other during the whole proceſs.

WOLFRAM. Tungſten and Wolfram have already been treated of in the article Acid of Tungsten; and the combinations of metals with the regulus of wolfram have been occaſionally mentioned under their reſpective titles. Little elſe remains therefore to be ſaid of this metallic ſubſtance, than to ſpecify its general characters.

The yellow matter, or calx of wolfram, turns blue by expoſure to light, and more intenſely if to the light of the ſun. By a ſtrong heat in a covered crucible, it becomes of a blueiſh black colour, with loſs of weight, which it recovers, together with its original yellow colour, by calcination, with acceſs of air. Theſe changes to the blue colour appear therefore to be partial reductions*. One hundred grains of the yellow calx, or acid, being put into a crucible with charcoal powder, well covered, and expoſed to a ſtrong heat, became converted into a button of a dark brown colour, and friable with a diminution of forty grains of the original weight. Its ſpecific gravity was 17.6; and upon examination with a glaſs, a congeries of metallic globules was ſeen, ſome of them of the ſize of a pin's head, which when broke exhibited a fracture reſembling ſteel. Part of this maſs being calcined became yellow as at firſt, and gained twenty-four per cent. in weight. It was not ſoluble in vitriolic or marine acid; but the nitrous acid, and aqua regia, converted it again into the yellow calx. The yellow calx itſelf could not be vitrified. Acetous acid converted the yellow colour to a blue.

When equal parts of ſulphur and the yellow calx were urged by a ſtrong heat, a blue friable maſs remained, weighing leſs than one-fourth of the whole.

WOOD. See Vegetables.

WOOD-LICE. See Millipedes.

WOOD-SORREL. See Acid of Sorrel.

WOOL†. The principal differences in wool conſiſt in the length and fineneſs of its filaments. That which has the fineſt filaments is reſerved for fine cloths. The moſt beautiful wool is brought to us from Spain. It is ſaid that the highland wool of Scotland is equal in quality to this. Mr. D'Aubenton has ſhewn that it may be produced in France of a quality not inferior to that of Spain, by folding the ſheep through the whole year, and chooſing the rams with care. Simple inſpection may eaſily lead to error reſpecting the fineneſs of wool, which it is important the manufacturer ſhould know with accuracy; he has propoſed a method of attaining that accuracy, by employing a micrometer for comparing,

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* De Luyarts on Wolfram, p. 58. Gmelin has alſo made a variety of experiments on this metallic ſubſtance. See Crell's Journal, Engliſh, iii. The papers are too long to be inſerted here, and the facts too inſulated to admit of abridgment.

† Berthollet on Dyeing, i. 123.

paring, by means of a microſcope, the fineneſs of the wool to be examined with that of other wools choſen as ſtandards*.

Though the long wool is not ſo fine as the Spaniſh, and cannot be employed for fine cloths, it is ſtill very uſeful for a variety of fabrics; and as the ſheep which produce it have much larger fleeces, the profit they bring is not inferior to that of the fine woolled ſheep; beſides, the cloths made of their wool, being cheaper, have a much more extenſive ſale. The proſperous ſtate of the woollen manufactures of England is partly owing to our abundance of this wool. But the breed of ſheep which produces one or the other kind of wool, is connected with the nature of their paſture, which ought to determine us in the choice of them.

Wool is naturally covered with a kind of greaſe, which preſerves it from moths. Reaumur † has obſerved, that a ſtuff may be preſerved from theſe inſects, by rubbing it with greaſy wool. Hence wool is not ſcoured till it is about to be dryed or ſpun.

In order to ſcour wool, it is put for about a quarter of an hour into a kettle, containing a ſufficient quantity of water, mixed with a fourth of putrid urine, heated to ſuch a degree as the hand can juſt bear, and it is ſtirred from time to time with ſticks; it is then taken out and put to drain: it is next carried in a large baſket to a ſtream of running water, where it is moved about till the greaſe is entirely ſeparated, and no longer renders the water turbid; it is then taken out and left to drain. It ſometimes loſes in this operation more than a fifth of its weight. The ſcouring ſhould be carefully performed, becauſe the wool is thereby better fitted to receive the dye.

The ammoniac or volatile alkali, formed in putrid urine, unites with the greaſe, producing a kind of ſoap which is ſoluble in water.

The wool is dyed in the fleece, or before it is ſpun, chiefly when it is intended to form cloths of mixed colours; or elſe it is dyed after being ſpun, and it is then intended principally for tapeſtry; but it is moſt commonly dyed after having been wrought into cloth.

When wool is dyed in the fleece, its filaments being ſeparate abſorb a larger quantity of the colouring particles than when it is ſpun; for the ſame reaſon woollen yarn takes up more than cloth; but cloths themſelves vary conſiderably in this reſpect, according to their degree of fineneſs, or the cloſeneſs of their texture: beſides, the variety in their dimenſions, the different qualities of the ingredients employed in dyeing, and a difference of circumſtances in the proceſs, prevent us from relying upon the preciſe quantities we find recommended for the proceſſes deſcribed. This conſideration ought to extend to all dyes.

For moſt colours, wool requires to be prepared by a bath, in which it is boiled with ſaline ſubſtances, principally with alum and tartar: but there are ſome dyes for which the wool does not require ſuch a preparation; then it muſt be well waſhed in warm water, and wrung out or left to drain. This is a general rule which ſhould be obſerved with reſpect to all the ſubſtances intended to be dyed, in order that the colour may penetrate them more eaſily, and be diſtributed more uniformly.

Mr. Monge has explained the operation of felting (feûtrage) and the effects of fulling, by the external conformation of the wool and hair of animals. He has made

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* Mem. de l'Acad. 1779. Inſtructions to ſhepherds and proprietors of flocks.

† Mem. de l'Acad. 1728.

made ſome curious obſervations * on this ſubject, of which the following are the chief:

Nothing particular can be diſcovered by means of the microſcope in the filaments of wool or in the hairs of animals; yet the ſurfaces of theſe bodies are not ſmooth: they muſt be formed either of ſmall laminæ placed over each other in a ſlanting direction from the root towards the point, like the ſcales of fiſh, which cover each other from the head of the animal to the tail, or more probably, perhaps, of zones placed one upon another as we ſee in the horns of animals.

If a hair be laid hold of by the root in one hand, and drawn between the fingers of the other, from the root towards the point, ſcarce any friction or reſiſtance is perceived, and no noiſe is heard; but if, graſping it by the point, it is paſſed in the ſame manner between the fingers of the other hand, from the point towards the root, a reſiſtance is felt, which did not take place in the former place, and a tremulous motion is perceptible to the touch, and a noiſe ſenſible to the ear.

We perceive then, that the texture of the ſurface of hair is not the ſame from the root towards the point, as it is from the point towards the root, and that a hair when preſſed muſt meet with greater reſiſtance in ſliding or moving towards the point than towards the root; but as it is this texture itſelf which forms the principal ſubject of Mr. Monge's memoir, it is neceſſary to confirm it by ſome further obſervations.

If, after having laid hold of a hair between the thumb and fore-finger, we rub them againſt each other in the longitudinal direction of the hair, it acquires a progreſſive motion in that direction towards the root. This effect depends neither on the nature of the ſkin of the finger, nor on its texture; for if the hair be turned, ſo that the point ſhall be placed where the root was before, its motion will now be in an oppoſite direction, that is, it will ſtill be towards the root.

Theſe obſervations, to which Mr. Monge adds ſome others, are related of human hair, taken as an example; but they are equally applicable to the filaments of wool, to horſe-hair, and to that of animals in general. The ſurface of all theſe bodies then is formed of rigid laminæ, laid upon each other like tiles, from the root to the point, which allow a progreſſive motion towards the root, but oppoſe one towards the point.

This ſtructure is the principal cauſe of the diſpoſition to felting (feûtrage) which the hair of animals generally poſſeſſes: the hatter, by ſtriking the flocculi of wool with the ſtring of his bow (archet), detaches and diſperſes in the air each of the filaments ſeparately; theſe fall back one upon another in all directions on the table, where they form a layer of a certain thickneſs; the workman then covers them with a cloth (I ſuppoſe linen), upon which he preſſes on all parts with his hands extended.

The preſſure brings the filaments of wool nearer to each other, and multiplies the points of contact; the agitation gives each of them a progreſſive motion towards its root, by means of which they entangle each other; and the laminæ of each filament taking hold of thoſe of the other filaments which are in an oppoſite direction, the whole is retained in the ſtate of cloſe contexture, which it had acquired by the preſſure.

In proportion as the texture becomes cloſer, the preſſure of the hands ought

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* Obſervations ſur la Mechaniſme du Feûtrage. Ann. de Chym. tom. vi.

to be increaſed, both in order to make it ſtill more compact, and to keep up the progreſſive motion and intermixture of the filaments, which now meet with greater reſiſtance: but during the whole of this operation, the filaments of wool lay hold of each other only, and not of the cloth, the fibres of which, as has been already obſerved, are ſmooth, and have not the ſame properties in this reſpect.

The aptitude for felting in wool and hair does not depend entirely on the ſtructure of their ſurface; it is not enough that each filament ſhould have a progreſſive motion towards its root; nor that the inclined laminæ, by laying hold of each other, ſhould retain the contexture in the ſtate to which it has been reduced by compreſſion: it is alſo neceſſary that the filaments ſhould not be ſtraight like needles; for, by a continuance of the motion and preſſure, each of them would continue its courſe progreſſively, without changing its direction, and the effect of the operation would be to remove them all from the centre, without producing any contexture. It is therefore neceſſary that each filament ſhould be crooked, ſo that the extremity neareſt the root ſhould be diſpoſed to change its direction continually, to entwine itſelf round freſh filaments, and to return back upon itſelf, if it ſhould be ſo determined by any change in the poſition of the reſt of its length.

Wool poſſeſſing this ſtructure naturally, is peculiarly fitted for this kind of work, and may be employed in it, without being ſubjected to any previous preparation; but the furs of rabbits, hares, and beaver are naturally ſtraight, and cannot be employed alone for felting, without having undergone a previous operation, which conſiſts in rubbing them, before they are ſtripped, with a bruſh moiſtened with a ſolution of mercury in nitrous acid; this liquor, by acting only on one ſide of the hairs, changes their rectilinear direction, and communicates to them that diſpoſition for felting which wool naturally poſſeſſes.

The operation of fulling woollen ſtuffs depends on the ſame property as felting.

The aſperity of the ſurface of the filaments of wool, and their diſpoſition to acquire a progreſſive motion towards the root, form an obſtacle to the ſpinning of wool, and the working it into ſtuffs. All the filaments muſt therefore be covered with a coat of oil, which by filling the cavities renders the aſperities leſs ſenſible, juſt as a coat of oil renders a fine file ſtill ſmoother. When the piece of ſtuff is wrought, it muſt be freed from that oil, which gives it a diſagreeable ſmell, renders it dirty, and would prevent it from taking the colour we wiſh to dye it: for this purpoſe, it is taken to the fulling-mill, where it is beaten with large beetles, in a trough of water, through which ſome clay has been diffuſed. The clay uniting with the oil, renders it ſoluble in the water, and both are carried off together, by freſh water brought thither by the machine; and after ſome time, the ſtuff is found clean ſcoured. See EARTH, FULLER'S.

But ſcouring is not the only object in fulling; the alternate preſſure of the beetles on the ſtuff, particularly when the ſcouring is advanced, produces an effect analogous to that of the preſſure of the hatter's hands; the filaments of wool, which compoſe a thread of the warp or of the woof, acquire a progreſſive motion, inſinuate themſelves into the adjoining threads, then into thoſe which are next, and preſently all the threads, both of the warp and woof, are felted together. The ſtuff is now found contracted in length and breadth, and participates both of the nature of cloth and of felt; it may be cut without being ſubject to ravel, and there is no neceſſity for hemming the different pieces of it employed to make a garment. If it be common woollen ſtocking web, the ſtitches are now no longer ſubject to run, when one of them happens to ſlip; finally, the threads of the warp and the woof, are now no longer ſo well defined, nor ſo diſtinct from each other, and the ſtuff being alſo thickened forms a warmer clothing.

Berthollet obtained a large proportion of acid of ſugar by abſtraction of nitrous acid from wool.

WORMS. See Earth Worms.

WORMWOOD. This vegetable affords a large quantity of vegetable alkali by incineration, which is the ſalt of wormwood of the ſhops. It does not differ from other alkalis when purified. The leaves of wormwood are intenſely bitter, and have a ſtrong and ſomewhat aromatic ſmell. They yield, according to Neumann, a conſiderable quantity of eſſential oil, poſſeſſing their whole ſmell, the bitter matter remaining in the extract.

Y

YEAST. The uſe of yeaſt in promoting the vinous fermentation appears to be in ſome reſpect that of rendering the proceſs more uniform through a conſiderable maſs. But the chief efficacy of its action does not ſeem to be well underſtood. Bodies remain unchanged ſo long as the elective attractions are ſatisfied or in equilibrio. Chemical operations are effected in no other way than by diſturbing this ſtate of repoſe, which may be done, either by mere change of temperature, or by the addition of ſome other principle. Thus an ignited coal may be conſidered as the ferment by which a large quantity of combuſtible matter may be made ſpeedily to change its ſtate of combination throughout. And ſo likewiſe it may be conceived, at leaſt hypothetically, that the addition of a body conſiderably changed by the fermentative proceſs may haſten the commencement of a ſimilar change in a larger maſs. See Fermentation.

Z

ZAFFRE, or SAFFRE, is the reſiduum of cobalt, after the ſulphur, arſenic, and other volatile matters of this mineral have been expelled by calcination. It is therefore a calx of cobalt, of a gray or reddiſh colour. The uſe of cobalt is to produce a very fine blue colour, when it is melted with fuſible and vitrifiable matters.

The calx of cobalt is the ſole cauſe of the blue colour produced by zaffre. But as the quantity of regulus contained in cobalt is variable, ſome zaffres furniſh more blue than others. The heterogeneous fixed matters contained in cobalts contribute likewiſe according to their quantity to the greater or leſs intenſity of the blue colour. For this reaſon the manufacturers of zaffre from cobalt make frequent eſſays of the roaſted ore, by mixing it with vitreous matters, to diſcover the intenſity and beauty of the blue colour.

Good cobalt calcined would form too deep a blue, and almoſt a black glaſs, if it were not previouſly mixed with a certain quantity of vitreous fritt. In the manufacture of zaffre, therefore, the calx of cobalt, the ſtrength of which has been previouſly determined by eſſays, is mixed with ſuch a quantity of ſand, or of powdered flints and quartz, that with the addition of ſome ſaline flux a deep blue glaſs may be formed.

The zaffre that is commonly ſold, and which comes from Saxony, is a mixture of calx of cobalt with ſome vitrifiable earth. It is of a gray colour, as all the calces of cobalt are before vitrification. Some zaffres are dearer than others, according to the intenſity of the colour which they are capable of producing. Zaffre is employed in the manufacture of pottery and of porcelain, for painting the ſurface of the pieces of ware, upon which it is applied together with ſome ſaline flux, previouſly to the baking or glazing, that the ſame fire may alſo vitrify this colouring material.

The blue of zaffre is the moſt ſolid and fixed of all the colours that can be employed in vitrification. It ſuffers no change from the moſt violent fire. It is ſucceſsfully employed to give ſhades of blue to enamels, and to the cryſtal glaſſes made in imitation of ſome opake and tranſparent precious ſtones, as the lapis lazuli, the turquois, the ſapphire, and others of this kind. See AZURE; COBALT; INK, SYMPATHETIC; and SMALT.

ZEOLITE. This ſtone was unknown to mineralogiſts before the celebrated Cronſtedt gave a deſcription of it.

It is uſually of a ſemi-tranſparent white; but this colour is ſometimes altered by metallic mixtures, and then it aſſumes all kinds of tinges.

The name of zeolite has been given to it on account of its property of forming a jelly with acids. This property has even been conſidered as excluſive and characteriſtic. But Mr. Swab has very juſtly obſerved, in the year 1758, that all zeolites do not poſſeſs this property; and Mr. Pelletier has proved, in the xxth volume of the Journal de Phyſique, that this property is not even peculiar to zeolites.

The exiſtence of zeolites in certain lavas has induced ſome naturaliſts to conſider them as produced by the decompoſition of volcanic earths.

The moſt beautiful zeolites come to us from the iſlands of Ferroe near Iceland. The form of this ſtone is conſtant. The radii which compoſe it diverge as it were from a central point, and are diſpoſed after the manner of a fan. The radii which terminate at the external ſurface, are found to exhibit a trihedral or tetrahedral pyramid.

The white zeolite affects two principal forms, the cubic and the tetrahedral priſm, ſometimes flattened and terminated by an obtuſe tetrahedral pyramid.

Its ſpecific gravity is from 2.1 to 3.15.

The zeolite, expoſed to a ſtrong heat, dilates, and ſwells more or leſs, according to the proportion of water it contains, and at length melts into a porous ſcoria. Soda fuſes it with effervefcence; the borate of ſoda diſſolves it more difficultly; and the phoſphates of urine have ſcarcely any action upon it.

Bergman obtained from one hundred parts of the red zeolite of Adelfort, 83 ſilex, 9.5 clay, 6.5 pure lime, and 4 water.—Letters on Iceland, p. 370.

The white zeolite of Ferroe contains, according to Pelletier, 50 ſilex, 20 clay, 8 lime, and 22 water.—Journal de Phyſique, tom. xx.

Meyer obtained from a radiated zeolite 58.33 ſilex, 17.5 clay, 6.66 lime, 17.5 water.

Kirwan obſerves, that the cryſtallized ſpecies contain more water than the others.

ZINC is a ſemi-metal, of a blueiſh white colour, ſomewhat brighter than lead; of conſiderable hardneſs, and ſo malleable, as not to be broken with the hammer, though it cannot be much extended in this way. It is very eaſily extended by the rollers of the flatting mill. When broken by bending, its texture appears as if compoſed of cubical grains. On account of its imperfect malleability, it is difficult to reduce it into ſmall parts by filing or hammering; but it may be granulated, like the malleable metals, by pouring it when fuſed, into cold water; or, if it be heated nearly to melting, it is then ſufficiently brittle to be pulverized. It melts long before ignition, at about the 700th degree of Fahrenheit's thermometer; and, ſoon after it becomes red-hot, it burns with a dazzling white flame, of a blueiſh or yellowiſh tinge, and is calcined with ſuch rapidity, that it flies up in the form of white flowers, called the flowers of zinc, or philoſophical wool. Theſe are generated ſo plentifully, that the acceſs of air is ſoon intercepted; and the combuſtion ceaſes, unleſs the matter be ſtirred, and a conſiderable heat kept up. The white calx of zinc is not volatile, but is driven up merely by the force of the combuſtion. When it is again urged by a ſtrong heat, it becomes converted into a clear yellow glaſs. If zinc be heated in cloſed veſſels, it riſes without decompoſition. Zinc appears to be the moſt volatile of metallic ſubſtances except the regulus of arſenic.

The diluted vitriolic acid diſſolves zinc: at the ſame time that the temperature of the ſolvent is increaſed, and much inflammable air eſcapes, an undiſſolved reſidue is left, which conſiſts of plumbago. The theories of this ſolution, and the diſengagement of inflammable air, are perfectly ſimilar to thoſe which have been before explained in the article Iron. As the combination of the vitriolic acid and the calx proceeds, the temperature diminiſhes, and the vitriol of zinc, which is more ſoluble in hot than cold water, begins to ſeparate, and diſturb the tranſparence of the fluid. If more water be added, the ſalt may be obtained in fine priſmatic four-ſided cryſtals. The white vitriol, or copperas, uſually ſold, is cryſtallized haſtily, in the ſame manner as loaf-ſugar, which on that account it reſembles in appearance: it is ſlightly effloreſcent. The white calx of zinc is ſoluble in the vitriolic acid, and forms the ſame ſalt as is afforded by zinc itſelf.

Diluted nitrous acid combines rapidly with zinc, and produces much heat, at the ſame time that a large quantity of nitrous air flies off. The ſolution is very cauſtic, and affords cryſtals by evaporation and cooling, which ſlightly detonate upon hot coals, and leave a calx behind. This ſalt is deliqueſcent.

Marine acid acts very ſtrongly upon zinc, and diſengages much inflammable air; the ſolution, when evaporated, does not afford cryſtals.

Water impregnated with fixed air diſſolves a conſiderable proportion of zinc. The other acids have not been tried.

Zinc is precipitated from acids by the ſoluble earths and the alkalis: the latter re-diſſolve the precipitate, if they be added in exceſs.

Zinc decompoſes, or alters, the vitriolic neutral ſalts in the dry way. When fuſed with vitriolated tartar, it converts that ſalt into liver of ſulphur; the zinc at the ſame time being calcined, and partly diſſolved in the hepar. In this operation, the vital air of the acid combines with the zinc, and calcines it; at the ſame time that, according to the ancient theory, the phlogiſton of the metal combines with the acid baſe, and converts it into ſulphur. In the new theory, the tranſition of phlogiſton is conſidered as hypothetical and unneceſſary: becauſe the metal and the ſulphur being taken to be ſimple ſubſtances, the vitriolic acid becomes ſulphur, merely by the loſs of its vital air; and the zinc becomes calcined, merely by the acquiſition of the ſame ſubſtance.

When pulverized zinc is added to fuſed nitre, or projected together with that ſalt into a red hot crucible, a very violent detonation takes place; inſomuch that it is neceſſary for the operator to be careful in uſing only ſmall quantities, leſt the burning matter ſhould be thrown about. The zinc is calcined; and part of the calx combines with the alkali, with which it forms a compound ſoluble in water.

Zinc decompoſes common ſalt, and alſo ſal ammoniac, by combining with the marine acid. The filings of zinc likewiſe decompoſe alum, when boiled in a ſolution of that ſalt, probably by combining with its exceſs of acid.

Sulphur, though its action is almoſt general on metallic ſubſtances, does not combine with zinc. This property affords a ready means of purifying the ſemi-metal, by projecting ſulphur upon it, when melted in a ſhallow crucible. It has been a ſubject of remark among chemiſts, that many of the zinc ores conſiſt of this ſemi-metal combined with ſulphur, though art has not yet diſcovered the means of effecting the ſame combination. But the difficulty is removed by the conſideration, that the ſulphur does not unite with zinc itſelf, yet it readily does with its calx, and forms a compound ſimilar to the zinc ores, called blendes; in which, for that reaſon, the zinc may be preſumed to exiſt in the calciform ſtate.

Liver of ſulphur does not combine with zinc, either in the humid or dry way.

Moſt of the metallic combinations of zinc have been already treated of. It forms a brittle compound with antimony; and its effects on manganeſe, wolfram, and molybdena, have not yet been aſcertained.

Native zinc has been very ſeldom found. The calciform ores of zinc are the zinc ſpar, of a whitiſh gray colour, reſembling a lead ſpar; and the impure calx called calamine, which is of a white, gray, yellow, brown, or red colour, containing iron, clay, calcareous and other earths, and lead. The ore called blende, mock-lead, or black-jack, conſiſts of zinc mineralized with ſulphur and iron: of this there are ſeveral varieties. They are in general of a plated texture, and frequently of a quadrangular form, like galena, or potters' lead ore, though they are conſiderably leſs heavy. Theſe ores are found in various parts of Europe, and in conſiderable plenty in the mine counties of England. See Ores.

Native zinc may be aſſayed, in the humid way, by the mineral acids. When it is diſſolved in theſe, if there be any other metal preſent, it may be precipitated by the addition of a known quantity of zinc. The weight of calx of zinc precipitated by mild alkali from its vitriolic ſolution, will amount to 193 grains for every 100 of the metal it repreſents. The ſulphureous zinc ores muſt be carefully treated with nitrous acid; which will diſſolve the zinc, and leave the ſulphur. Extraneous metals may be precipitated, and the quantity of zinc aſcertained, as before.

The eſſay of calamines is ſometimes made by pounding and mixing them with charcoal, and then heating them in a crucible covered with a copper plate. The reduced zinc riſes, and converts the copper into braſs; and in this way ſome judgment may be formed of its value in the operation of braſs-making. Moſt of the zinc, whether in the metallic ſtate or in the form of an impure calx, called cadmia fornacum, is obtained in the roaſting of various kinds of ores at Ramelſberg. For this purpoſe the interior part of the furnace is kept cold by wetting it: by which means the volatilized zinc is condenſed, and falls into a cavity, containing charcoal duſt, which defends it from calcination.

The proceſs for obtaining zinc from its ores by diſtillation, which is practiſed in England, and ſaid to have originally been derived from the Chineſe, is performed in a furnace in the form of a circular oven; in which are placed ſix pots, each about four feet in height, and of a conical ſhape, reſembling an oil jar. Into the bottom of each pot an iron tube is inſerted, which paſſes through the floor of the furnace into a veſſel of water. Theſe pots are filled with a mixture of calamine and charcoal; and their mouths are then cloſe ſtopped with clay. The fire being then properly applied, the metallic vapour of the calamine iſſues through the iron tube, which is the only place where it can eſcape. In this way it is condenſed into ſmall particles in the water; which are afterwards melted into ingots for ſale, under the name of ſpelter. The ſubſtance ſold in London by the name of ſpelter, is a kind of ſoft braſs, in a granulated form, which is uſed by the braziers and others for ſoldering.

The chief purpoſe to which zinc is applied conſiſts in the fabrication of braſs and other gold-coloured mixtures. Its calces and ſalts have been occaſionally employed in medicine.

Dr. George Fordyce made an experiment by diſſolving zinc in the vitriolic acid, and precipitating it by an alkali. The object was to aſcertain from the weights of the metal, the calx, and the neutral ſalt produced, whether any of the acid entered into the compoſition of the calx, or of the inflammable air. As the quantity of acid was found to be undiminiſhed, the ſtrict conſequence will be, that the additional weight of the calx comes from the water, which muſt have combined either in whole or in part with the metal, and that the inflammable air which eſcapes is produced either by the water or the metal. But as it is aſcertained from other experiments that the calx contains vital air, this principle ſhould appear to be one of the conſtituent parts of the water, and conſequently the inflammable air will be the other. As this experiment appears to poſſeſs peculiar accuracy, and is of great importance relative to the theory of phlogiſton, and the compoſition of water, I ſhall give the account nearly in the Doctor's own words *.

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* Philoſoph. Tranſ. for 1792, p. 375.

He took a portion of zinc and diſſolved it in vitriolic acid, with which it made a clear ſolution (without any of that black matter which commonly ſeparates during its ſolution when we employ zinc imported from abroad). After precipitating it by an alkali, and expoſing the calx to the air, it remained of a pure white; ſo that it could contain no iron. This zinc was reduced to its perfect metallic form by breaking it into ſmall particles, and melting it with black flux, taking that part of it only which was at the bottom of the crucible.

He reduced this metal to a calx, by diſſolving it in vitriolic acid diluted with water, and precipitated it by kali purum diſſolved in water.

In doing this the acid ſhould be diluted with four or five times its weight of water, and the zinc ſhould be diſſolved very ſlowly, avoiding heat as much as poſſible during the ſolution. If this precaution is not taken, a quantity of volatile vitriolic acid will be produced, and ſpoil the experiment.

In the precipitation the alkali is apt to re-diſſolve the calx, if care be not taken to uſe it in ſolution in water, and that the ſolution is diluted with a large quantity of water: the proportion in which the water is in aqua kali puri of the London Diſpenſatory is a convenient ſolution of the alkali.

Care muſt likewiſe be taken, in the precipitation, that the ſolution of the kali be poured into the ſolution of the zincum vitriolatum in water by a little at a time, and that the whole be perfectly mixed together before a freſh quantity is poured in, otherwiſe part of the calx will be re-diſſolved. It is farther neceſſary that the exact quantity of kali purum be uſed: if too little is uſed, the whole calx will not be ſeparated; if too much, part of the calx will be re-diſſolved. It is alſo neceſſary that the alkali be perfectly pure, eſpecially free from fixed air, as that would be transferred to the calx; and as it flies off when the kali is ſimply united with vitriolic acid, the accuracy of the experiment would be thus deſtroyed.

The weight of the calx, by which it exceeds the weight of the metal, ſhews that there is a ſubſtance added to the whole metal; or that, while ſome ſubſtance is driven off, another is added in greater quantity; ſince it is clear, from various experiments, that all matter gravitates, and that all the ſubſtances found on this earth, which have been tried, gravitate equally. This additional matter muſt be added to the metal either from the acid, the alkali, the water uſed in the ſolution, the air lying on the ſurface of the materials during the time of the operation, or it muſt come through the veſſels in which the operation is performed. To aſcertain this, he made the following experiment.

He took a large quantity of vitriolic acid, purified by diſtillation (about two pounds, it not being material what quantity was taken exactly); he diluted it with diſtilled water about four or five times its weight by gueſs (the exact proportion being alſo immaterial); he applied to 1000 grains of this diluted acid a ſufficient quantity for ſaturation of aqua kali puri, of the London Diſpenſatory, rendered pure from fixed air, as is preſcribed in the proceſs of the College; he poured in the aqua kali puri to the diluted acid, by a little at a time, till it was nearly ſaturated. He then poured in ſome juice of violets, which gave the whole a red colour. He continued to add aqua kali puri, by a little at a time, till the red colour juſt diſappeared. He added the aqua kali puri to the acid, rather than the acid to the alkali, becauſe the loſs of the red colour at the point of ſaturation can be diſcerned much better than the loſs of the yellow colour, which the alkali intermixes with the natural hue.

He aſcertained the weight of the aqua kali puri, by weighing the bottle containing it before any was poured into the acid, and after the ſaturation took place; the deficiency of weight afterwards being the weight of the aqua kali puri applied to the acid for the ſaturation; this was 10147 grains. He alſo weighed the veſſel with the acid before the aqua kali puri was poured in, and afterwards; and found the increaſe of weight to be exactly the ſame as the weight of the aqua kali puri and juice of violets, ſo that nothing was loſt during the operation.

This experiment was three times repeated, taking the point of ſaturation from the eye. The quantities of aqua kali puri employed were found to be 10147 grains, 10145 grains, 10150 grains.

He took 10148 grains, being the mean of the three experiments, and applied it to 1000 grains of the ſame vitriolic acid; evaporated the water to dryneſs, and heated it to a red heat, to drain off the whole of the water; and found 978 grains of kali vitriolatum remaining. By this means he aſcertained the quantity of kali vitriolatum produced from 1000 grains of the diluted vitriolic acid, when ſaturated with kali.

He took 1000 grains of the diluted vitriolic acid, and put it into a veſſel conſiſting of a ſpherical bulb of glaſs, with a neck or tube which communicated with another ſpherical bulb on the oppoſite ſide of which was alſo a neck or tube. The figure of this double bottle or veſſel will be more readily apprehended, if, with the exception of its being much larger, the reader imagine a thermometer to have two bulbs, the one at the extremity of the tube, and the other a little higher up; the portion of the tube, left between the two bulbs, being in a line with the other portion of the tube, which conſtitutes the real neck or aperture of the whole veſſel. The vitriolic acid was conveyed by means of a funnel into the lower globular part, and zinc was added until it would diſſolve no more. During the ſolution the inflammable air was caught, which weighed nine grains, and was nearly twelve times as light as atmoſpheric air. The lower bulb was ſufficiently capacious to contain the whole of the acid and zinc, and to admit of the compound bottle being laid on its ſide without the fluid running from the one part into the other. Dr. Fordyce denominates the outer globe A, the inner globe B, the tube of communication between them C, and the neck or tube into which the materials were admitted D.

The ſolution was terminated in five days; when part of the tube D being broke off, it was left to ſtand for four-and-twenty hours, to allow the inflammable air remaining in the veſſel to fly off, and give place to the air of the atmoſphere; which happened ſpontaneouſly from the different ſpecific gravities of the two vapours.

The veſſel containing the ſolution of the zinc was now laid upon its ſide, and 10148 grains of aqua kali puri were introduced by a crooked funnel into the globe B, being the quantity ſufficient to ſaturate 1000 grains of vitriolic acid, as before determined. Then the tube D was hermetically ſealed, and the whole weighed. The veſſel was then raiſed, ſo that the globe A was undermoſt; this was done very gradually, ſo that the aqua kali puri was gradually added to the ſolution of the zinc; when a little was poured in, the veſſel was brought into an horizontal poſition again, and ſhaken a little; this was repeated till the whole of the aqua kali puri was poured in. The zinc was thus precipitated in the form of a calx. It was ſuffered to ſtand for forty-eight hours; no alteration of the weight had taken place; therefore nothing had entered through the glaſs to give additional weight to the zinc in order to calcine it.

The next ſtep was to open the tube, which was done under water, and in an atmoſphere of the ſame heat in which it was ſealed, to wit, 57° of Fahrenheit's thermometer. The air was neither diminiſhed nor increaſed, none of the water being driven into the apparatus by the weight of the atmoſphere, and none being thrown out. On heating the globe B, ſo as to drive out ſome of the air, it was found to be of the ſame purity nearly as that of the atmoſphere, being tried by the application of nitrous air produced from ſolution of mercury.

The weight therefore, which the calx had gained, aroſe neither from any ſubſtance paſſing through the glaſs, nor from the ſuperincumbent air during the precipitation. It muſt therefore be either from the acid, the alkali, or the water.

To determine whether the acid or alkali gave the weight to the calx of the zinc, he waſhed out the kali vitriolatum, formed by the combination of the vitriolic acid and the kali, with pure water repeatedly applied, until it came away as pure as when applied to all ſenſible trials. The quantity of water uſed was above four pounds. He evaporated this water to dryneſs, and heated the maſs red hot, to expel the whole of the water; it weighed ſeven grains more than the vitriolated tartar procured from applying the acid and alkali as above. After evaporating the water, he diſſolved the maſs again in 40 ounces troy weight of pure water; a yellowiſh powder ſeparated. The ſolution of the vitriolated tartar, cleared of this powder, was again evaporated to dryneſs, and the water of cryſtallization driven off. It now weighed 976$\frac{1}{16}$ grains, which is barely two grains leſs than the vitriolated tartar he obtained from the acid and alkali applied ſimply together, without the intervention of the zinc.

The vitriolated tartar now obtained was free from any mixture. The additional weight of the calx of the zinc did not ariſe therefore from either the acid or the alkali; it remains therefore, that it aroſe from the water.

The weight of the calx of the zinc was aſcertained by drying it after waſhing out the vitriolated tartar, heating it to a red heat, and afterwards weighing it. The weight of the zinc diſſolved in ſaturating the acid was 164 grains: the weight of the calx 220 grains. The additional weight was therefore 56 grains.

If it aroſe from the water, then a quantity of water, equal to the weight by which the calx exceeds the metal, muſt be loſt in the operation. To determine this, he performed a diſtillation in the following manner:

He put 1000 grains of the ſame diluted vitriolic acid into the globe A of the ſame apparatus, then introduced the quantity of aqua kali puri found neceſſary to ſaturate it. The tube D was then bent downwards about the middle, and the apparatus brought to an horizontal poſition; ſo that the bent part of the tube was in a perpendicular direction downwards: to this he affixed a ſmall phial, and weighed the whole. He then put the globe B in a box filled with ice, and applied heat to the globe A, ſo as to diſtil over the water into the globe B, the liquor never being brought to the boiling point. When the matter in the globe A became dry, the heat was increaſed to a red one, to diſtil over likewiſe the water of cryſtallization. The whole apparatus was now weighed, and found not to have loſt a grain; nor was there any water in the phial. He then cracked the tube C, by applying a red hot iron to it, and letting a drop of cold water fall upon it. He next weighed the globe B with the water in it, then poured out the water, and let the glaſs dry. He weighed the glaſs; the deficient weight from the former weighing, being the weight of the water, was 10098 grains.

He repeated the experiment with this difference: he put 1000 grains of the ſame vitriolic acid into the globe A, then introduced the quantity of zinc ſufficient to ſaturate it: he took the weight of the inflammable air as before, and found it nearly the ſame in weight and quality. The ſame quantity of aqua kali puri was then introduced through a funnel as in the former experiment, then the tube was bent downwards, and a phial applied to it as before. The whole apparatus was weighed after the diſtillation, and found not to have loſt any ſenſible quantity of weight, nor was there any water in the phial. The phial being detached, and the tube broken as before, the globe weighed again when dry, the deficiency was leſs than in the former experiment by 63 grains, which is two grains leſs than the additional weight of the calx above the metal and the inflammable air taken together; and therefore Doctor Fordyce concludes that matter occaſioning the additional weight of the calx above that of the metal and *the inflammable air* are both produced from the water.

APPENDIX.

IN the following tables of chemical compounds, the reader is preſented with a view of as much as could be collected, with conſiderable induſtry, of their ingredients and general properties. It is unneceſſary to inſiſt on the extreme utility which might reſult to the practical as well as philoſophical chemiſt, if theſe could have been aſcertained to the utmoſt accuracy of weight, meaſure, and purity. Much advantage may neverthelefs be derived from them in their preſent imperfect ſtate, which is capable of great and daily improvement. Every practical chemiſt may benefit both himſelf and others, by carefully tabulating in this manner ſuch reſults as he can depend on; for much of experimental labour would be ſpared to every active cultivator of this ſcience, if it were poſſible, for the moſt part, to extract from tables ſuch documents as might nearly foretell what would happen in any projected experiment. Theſe tables will point out to the ſtudent what departments more particularly require cultivation. The preſent limits neceſſarily excluded an inſertion of the authorities, and various other intereſting particulars; which are indeed the leſs neceſſary, becauſe the whole demands an aſſiduous experimental examination. A philoſopher, in the fortunate circumſtances to proſecute ſo arduous an undertaking; in poſſeſſion of all the materials in their utmoſt purity, of the knowledge to perform it with effect, and of the ſpirited attachment to ſcience to apply his time to this purſuit, would do infinitely more ſervice to ſociety, than the inventors of a multitude of theories.

The tables require no other explanation than that the ſubſtance or principle in any horizontal compartment, united with the ſubſtance or principle at the head of any column, will form the compound deſcribed in the ſquare, common to both.

TABLE I. *Binary Compounds of ſuch Principles as*

Simple Principles.	Vital air.	Azotic air.	Inflammable air.	Baſis of fixed air.	Sulphur.
Vital air. Specific gravity 1,36.					
Azotic air. Specific gravity 1,19.	Atmoſ. air by mixture. Nitrous air by combin. Nitrous acid. Aeriform. Aqueous ſolution.				
Inflammable air. Specific gravity 0,09.	Water ? Sp. gr. 1000.	Mixture. Volatile alkali. Aeriform ſp. gr. 0,73. Aqueous ſol. Spirituous ſol.			
Baſis of fixed air. Pure charcoal ?	Aerial acid, or fixed air. Aëriform ſp. gr. 1,84. Aqueous ſolution. Spirituous ſolution.	Qu.	Heavy inflam. air. *Ardent ſpirit ?*		
Sulphur.	Vitriolic air. Sp. gr. 1,88 Aqueous ſolution, or ſulph. acid. Vitriolic acid. Aqueous cryſtallized. ——— liquid.	Qu.	Hepatic air. Aeriform. Aqueous ſol. Spirituous ſol.	Qu.	
Phoſphorus.	*Phoſphoreous acid ?* Phoſphoric acid. Dry or glacial. Aqueous ſolution. *Spirituous ſolution ?*	Qu.	*Phoſphoric air ?*	Qu.	Inflammable compound.
Veg. alkali. Solid. Aqueous ſolution. Spirituous ſolution.	Qu.	Qu.	Qu.	Qu.	Hepar. Aqueous ſolution.
Min. Alkali. Solid. Aqueous ſolution. Spirituous ſolution.	Qu.	Qu.	Qu.	Qu.	Hepar. Aqueous ſolution.
The earths. Solid.	Qu.	Qu.	Qu.	Qu.	Hepars.
Metals. Solid malleable.	Calces.	Qu.	Qu.	Plumbagos. Qu. other compounds.	Ores.
Baſes of acids, not hitherto exhibited in a ſeparate ſtate.	Acids, with one or more baſes, and different proportions of vital air.	Qu.	Qu.	Qu.	Qu.

have not been hitherto decompoſed.

Phoſphorus.	Veg. alkali.	Mineral alkali.	The earths.	Metals.
Hepar.				
Hepar.	Mixture.			
Hepar.	Aqueous combination and in the dry way glaſs.	Aqueous combination and in the dry way glaſs.	Glaſs.	
Ores.	Qu. direct. Indirect combination by precipitation. But *not unleſs calcined?*	Qu. direct. Indirect as with vegetable alkali.	No direct combination. *Indirect as with veg. alk.?*	
Qu.	Qu.	Qu.	Qu.	Qu.

TABLE II. *Compounds conſiſting in general of*

Component Parts.	Veget. alkali. Deliqueſcent. Aqueous ſolution. Spirituous ſolution.	Mineral alkali. Deliqueſcent. Soluble in water. ——— in ar. ſp.	Volatile alkali. Aeriform. Soluble in water. ——— in ar. ſp.	Vitriolic acid. Aeriform ? Aqueous, cryſtallizable. Sp. gr. 2,125 at moſt. Sp. gr. 2,00, Kirwan's ſtandard.	Sulphureous acid Aeriform, but condenſible by extreme cold. Aqueous ſolution.
Siliceous earth. Pure white powder taſteleſs. Sp. gr. 2,6. Inſoluble in water or ardent ſpirit. Infuſible ?	With water. Liquor of flints. Deliqueſcent ? In the dry way glaſs.	With water. Liquor of flints. Deliqueſcent ? In the dry way glaſs.	No direct union.	No direct union.	No direct union.
Calcareous earth. White powder. Sp. gr. 2,3. Cauſtic taſte. Heats with water, and diſſolves in 680 times its weight. Acts ſlightly on ard. ſpi. Infuſible.	With water ? In the dry way glaſs.	As the veg. alk. ?	Qu. ?	Selenite, gypſum, or plaiſter. Cryſtalliz. permanent. Sp. gr. about 2,3. Soluble in 500 parts of water. 32 parts earth. 47 acid ? 21 water ?	Combination. Saline ? or becoming ſo by expoſure to the air ?
Argillaceous earth. White powder taſteleſs. Sp. gr. about 2,0. Forms an adheſive paſte with water, but is not ſoluble in leſs than 7,000 times its weight. Inſol. in ar. ſp. ? Infuſible, but contracts and hardens by heat.	With water no action ? In the dry way glaſs ?	As the veg. alk. ?	Qu. ?	Alum. Perm. cryſt. if alk. be preſent, and acid in exceſs. Soluble in 15 p. water. 18 parts earth. 30 acid ? 52 water ? If the exceſs of acid be ſat with alk. the earthy ſalt becomes almoſt inſ.	Combination ?
Magneſian earth. White powder. Sp. gr. 2,33. Not more ſoluble in water or ard. ſp. than argil. earth. Infuſible.	With water ? In the dry way ?	As the veg. alk. ?	Qu. ?	Epſom ſalt. Bitter efflореſcent cryſt. Soluble in 1 p. water. 20 earth. 35 acid ? 45 water ?	Combination. Saline ?
Ponderous earth. White powder, cauſtic taſte. Sp. gr. 4,00 ? Soluble in 900 times its weight of water. Infuſible.	With water ? In the dry way ?	As the veg. alk. ?	Qu. ?	Ponderous ſpar. Permanent cryſtals. Sp. gr. 4,47. Inſoluble in water or ar. ſp. 84 earth. 16 acid. 0 water ?	Combination ? ?
Veg. alkali. White, concrete, deliqueſcent, cauſtic taſte. Very ſoluble in water. Sol. in ar. ſp.		Mixture.	Mixture.	Vitriolated tartar. Small permanent cryſtals. Soluble in 16 p. water. 53 alkali. 41 acid ? 6 water ?	Stahl's ſulphureous ſalt. Cryſtals permanent. Pungent taſte. Soluble in leſs water than vitriolated tartar, into which it becomes changed by expoſure to the air.
Mineral alkali. White, concrete, deliqueſcent, cauſtic taſte. Very ſoluble in water. Sol. in ar. ſp.	Mixture.		Mixture.	Glauber's ſalt. Large efflореſcent cryſt. Soluble in 3 p. water. 16 alkali ? 26 acid ? 58 water ?	Saline combination, reſembling Stahl's ſulphur. ſalt ?
Volatile alkali. Aeriform, pungent ſmell and taſte. Soluble in water. ——— in ard. ſp.	Mixture.	Mixture.		Vitriolic ammoniac. Permanent cryſtals. Soluble in 2 p. water. 56 alkali ? ? 31 acid ? 13 water ? Volatile or decompoſable by heat ?	Saline combination ?

Nitrous acid. Aeriform. Aqueous ſp. gr. 1,580. ——— Kirwan's ſtand. Aeriform with exceſs of azotic air, that is coloured nitrous acid. —— or with maximum of azotic air, viz. nit. air.	Marine acid. —— aeriform. —— aqueous ſp.gr. 1,196 Kirwan's ſtand. ſp. gr. 1,5.	Aerated marine acid. Aeriform. Aqueous ſolution.	Nitro-muriatic acid. Aeriform ? Aqueous.	Phoſphoric acid. Dry, deliqueſcent. Aqueous ſolution.	Aerial acid, or fixed air. Aeriform. Aqueous ſolution.
No direct union.	No direct union.	No direct union.	No direct union.	No direct union in the humid way; but it corrodes glaſs with heat. In the dry way glaſſy or glacial acid, taſteleſs, and not deliqueſcent ?	No direct union.
Nitrated lime. Deliqueſcent cryſtals. Sol. in 2 p. water, and in 7-10th p. ar. ſp. 32 earth. 43 acid. 25 water ?	Muriated lime. Deliqueſcent cryſtals. Sol. in 2 p. water, and in 7-10th p. ar. ſp. 40 earth ? 34 acid ? 26 water ? ?	Saline combination ?	Triple ſalt ? ?	Phoſphorated lime, or earth of bones. Scarcely ſoluble in water, unleſs by exceſs of acid.	Chalk. ſpar. Inſoluble, infuſible. 55 earth. 34 fixed air. 11 water.
Nitrated clay. Small deliqueſcent cryſtals, ſtyptic taſte.	Muriated clay. Small deliqueſcent ſtyptic cryſtals.	Saline Combination ?	Triple ſalt ? ?	In the dry way the glacial acid by ſtrong fuſion ? In the humid way. Qu. ?	Lac lunæ ?
Nitrated magneſia. Deliqueſcent cryſt. acrid and bitter. Very ſoluble in water and in ar. ſp. 27 earth. 43 acid. 30 water ?	Muriated mag Deliqueſcent ? cryſtals ? bitter acrid. Very ſol. in water, and in ardent ſpirit. 41 earth. 34 acid. 25 water.	Saline combination ?	Triple ſalt ? ?	Saline compound. Soluble in exceſs of acid, cryſtalliz. Not ſoluble in ar. ſp.	Aerated magneſia. Effloreſcent cryſt. nearly taſteleſs. Soluble in 40 p. water. Inſoluble in ar. ſp. ? 50 earth. 25 acid air. 25 water.
Nitrated p. earth. Of difficult ſolubility. Deliqueſcent ?	Muriated p. earth. Permanent cryſtals. Moderately ſoluble in water ? Inſol. in ar. ſp. ?	Saline combination ?	Triple ſalt ? ?	Qu. ?	Aerated pond. earth. Inſoluble native cryſtals. 78 earth. 20 acid. 2 vitriolated barytes.
Nitre. Permanent cryſtals, ſoluble in 7 p. water, and in 50 p. ar. ſp. 32 alkali. 63 acid. 5 water. Detonates with combuſtible matter.	Muriated veg. alkali, or ſalt of Sylvius. Permanent cryſtals. Sol. in 3 p. water and in 40 p. ar. ſp. 62 alkali. 32 acid. 6 water.	Aerated ſalt. Perm. cryſt. ſilvery bril. Soluble in water. ——— in ſpirit ? Comp. ſaid to differ from ſalt of Sylv. only in the exceſs of vital air. Detonates with combuſt. more ſtrongly than nit.	Nitre and ſalt of Sylvius ? Or a triple ſalt ? ?	Very ſoluble ſalts, difficultly cryſtal.	Mild alkali. Permanent cryſtals if ſaturated. Very ſoluble in water. Inſoluble in ar. ſp. ? 48 alkali. 20 acid. 32 water.
Rhombic nitre. Slightly deliqueſ. cryſt. Soluble in 1-3d p. water ? and in 13 p. ar. ſp. 50 alkali. 28 acid ? 22 water ? Detonates with combuſt.	Common ſea ſalt. Permanent cryſtals. Soluble in $3\frac{1}{2}$ p. water. Inſol. in ar. ſp. 42 alkali. 52 acid. 6 water.	Aerated ſalt. Very deliqueſcent.	Rhombic nitre and com. ſalt ? Or triple ſalt ? ?	Soluble ſalt. Cryſtallizable with exceſs of alkali. Effloreſcent.	Mild alkali. Effloreſcent cryſtals. 20 alkali. 16 acid. 64 water.
Nitrous ammoniac. Cryſtals; deliqueſcent ? Sol. in 1 p. water, and in 1 p. ar. ſp. 12 alkali ? 80 acid ? 8 water ? Decompoſed by heat with exploſion.	Sal. ammoniac. Perm. cryſt. not brittle. Sol. in 6 p. water, and in $12\frac{1}{2}$ ar. ſp. 40 alkali. 52 acid. 8 water. Sublimes entire in moderate heat.	Decompoſition of the alk. Products. Common marine acid. Water ? Azotic air.	Partial decompoſ. ? and triple ſalt ? Or two diſtinct ſalts ? ?	Soluble ſalt, cryſtalliz. with exceſs of alkali; but diſpoſed to fly off in evaporation. If the exceſs be the min. alk. it is the microcoſmic ſalt.	Mild vol. alkali. Slightly effloreſcent cryſt. 43 alkali ? 45 acid ? 12 water. Sublimes by gentle heat.

Component Parts.	Acid of borax. Permanent cryſtals. Sol. in 20 p. water, and in leſs ar. ſpirit. Riſes with boiling water, but not alone.	Acid of fluor. Aeriform. Aqueous ſolution. Spirituous ?	Acid of amber. Concrete ſublimate. Soluble in 24 p. water, and in about 3 ar. ſpirit.	Acetous acid. Aeriform. Aqueous. Aqueous aerated or radical.	Acid of tartar. Permanent cryſtals. Aqueous ſolution.
Siliceous earth.	In the dry way. Glaſs opake and frothy. Humid way. Diſſolves the earth precipitated from an alkaline ſolution.	Aeriform ſolution. Depoſits earth when paſſed thro' water. Humid way. Solution ; cryſtallizable.	No action.	No action.	No action ?
Calcareous earth.	In the dry way. Friable combination. Humid way. Solution.	Natural compound, or fluor ſpar. Gelatinous ſolution. Regenerated fluor.	Permanent cryſtals of very difficult ſolubility.	Acetated lime. Permanent cryſtals. Not ſoluble in ar. ſp. 36 earth. 58 acid. 6 water. Mere diſtillation deſtroys the acid.	Salt of very difficult ſolution. Tartarized lime.
Argillaceous earth.	In the dry way. Hard gray maſs. Humid way. By trituration combination of difficult ſolubility.	Adheſive gelatinous ſolution.	Priſmatic cryſtals not decompoſable by alkalis.	Salt of difficult cryſtallization.	Aſtringent ſolution. No cryſtals, but a clear gum-like maſs by evaporation. Soluble in water, but not deliqueſcent.
Magneſian earth.	In the dry way. Combination. Humid way. Irregular cryſtals. Ardent ſpirit deprives them of their acid.	Saline compound not ſoluble in water but by exceſs of acid. Cryſtals ſoluble in ardent ſpirit. Not decompoſed by heat, nor by any known acid.	Gummy ſaline deliqueſcent maſs.	Deliqueſcent gum-like maſs. Soluble in ar. ſp. gives out its acid by diſtillation.	Saline maſs, ſoluble with exceſs of acid and cryſtallizable.
Ponderous earth.	Qu. ?	Scarcely ſoluble Salt in powder.	Qu.	Deliqueſcent ſalt.	Qu.
Vegetable alkali.	By fuſion. Maſs of a glaſſy appearance. By ſolution. Cryſtallizable ſalt.	Gelatinous ſolution. By evaporation foliated.	Deliqueſcent bitter cryſtals, very ſoluble in water. Qu. In ardent ſpirit ?	Acetated veg. alkali. Vulg. foliated tartar. Deliqueſcent. Soluble in ardent ſpirit. 50 alkali. 41 acid. 9 water. Mere diſtillation deſtroys its acid.	Cryſtals of tartar. Soluble in 48 p. water ? 23 alkali. 77 acid, of which 34 are in exceſs. Soluble tartar. Sol. in 5 p. water ? 23 alkali. 43 acid.
Mineral alkali.	Common borax. Permanent cryſtals, with exceſs of alkali. Soluble in 18 p. water. 17 alkali, of which 8 are exceſs. 34 acid. 47 water.	Gelatinous ſolution. By evaporation foliated.	Permanent bitter cryſtals ſoluble in about 5 parts water ? Q. Ard. ſpirit ?	Acetated min. alkali. Permanent cryſtals. Soluble in ardent ſpirit.	Rochelle ſalt. Cryſtals ſlightly efflor. This combination has alſo a period of leſs ſolubility with exceſs of acid, as happens with the veg. alkali.
Volatile alkali.	Soluble cryſtallizable ſalt.	Gelatinous ſolution. Deliqueſcent cryſtals.	Cryſtallized ſalt. Permanent ? Soluble in water and in ar. ſp. Fuſible and totally evaporable.	Saline ſolution, called ſpirit of Mindererus. Riſes by heat firſt pure alkali, then acid, then neutral ſublimation.	Tartarized ammoniac. Cryſtallized. Soluble in water. Leſs ſoluble if the acid be in a determinate exceſs.

Empyreumatic acid of tartar. Aqueous.	Acid of ſugar. Cryſtallized. Soluble in 2 parts water, and in $2\frac{1}{2}$ p. ar. ſpirit, alſo in ether and all oils.	Acid of galls. Cryſtals. Soluble in 24 p. water, and in 4 p. ar. ſpirit.	Acid of lemons. Cryſtals. Soluble in water and in ar. ſpirit.	Acid of apples. No cryſtals. Aqueous ſol. Spirituous ſol.	Acid of benzoin. Concrete inflammable ſublimate. Sol. in 500 p. water, in a few p. ar. Spirit, and in oils.
No action.	No action?	No action.	No action.	No action.	No action.
Saline compound. Qu ?	Inſoluble compound. 46 earth. 48 acid. 6 water. Decompoſed by fire, but by no acid yet known.	Soluble ſalt.	Salt of very difficult ſolution. Inſoluble in ar. ſpirit.	Cryſtallized ſalt, Soluble in boiling water. Inſoluble in ar. ſpirit.	Cryſtals of ſparing ſolubility.
Compound ?	Yellow aſtringent maſs. Not cryſtallizable. 44 earth. 56 acid and water.	Qu.	Salt of difficult ſolution.	Salt of difficult ſolution.	Aſtringent ſalt.
Compound ?	White ſaline powder. 35 earth. 65 acid and water.	Soluble ſalt.	Salt of difficult ſolution.	Deliqueſcent ſalt.	Cryſtall. ſalt. Eaſily ſoluble in water. In ardent ſpirit ?
Compound ?	Compound of difficult ſolubility. Cryſtalliz. with exceſs of acid.	Soluble ſalt.	Salt of difficult ſolution.	Cryſtall. ſalt, very ſparingly ſoluble.	Qu.
Cryſtallizable and ſoluble compound.	Compound of difficult cryſtallization, unleſs one of the two principles be in exceſs. Soluble in water and in ardent ſpirit. If the acid be in a determinate exceſs, it forms ſalt of ſorrel.	Salt.	Deliqueſcent ſalt.	Deliqueſcent ſalt.	Deliqueſcent feather-like cryſtals.
Cryſtallizable and ſoluble compound.	Salt of ſparing ſolubility. Cryſtalliz. Inſoluble in ar. ſpirit.	Salt.	Deliqueſcent ſalt.	Deliqueſcent ſalt.	Eﬄoreſcent cryſtals.
Saline compound ?	Cryſtallizable ſalt. Very ſoluble in water. Inſoluble in ar. ſpirit.	Salt.	Salt. Deliqueſcent ?	Deliqueſcent ſalt.	Small deliqueſcent cryſtals.

Component Parts.	Empyreumatic acid of wood. Aqueous ſolution.	Empyreumatic acid of ſugar, &c. Aqueous ſolution. Spirituous ſolution.	Acid of camphor. Bitter cryſtals.	Acid of milk. Aqueous ſolution. Not cryſtallizable.	Acid of ſugar of milk. White powder. Sol. in 80 p. water. Cryſtallizable. Inflammable.
Siliceous earth.	No action.	No action.	No action.	No action.	No action.
Calcareous earth.	Saline compound.	Soluble ſalt. Not cryſtallizable.	Qu.	Deliqueſcent ſalt.	Inſoluble combination.
Argillaceous earth.	Qu.	Gummy aſtringent maſs.	Qu.	Deliqueſcent ſalt.	Inſoluble combination.
Magneſian earth.	Saline compound.	Gummy maſs opake, and hard when dry.	White pulverulent ſalt.	Cryſtall. ſalt. Deliqueſ.	Inſoluble combination.
Ponderous earth.	Saline compound.	Qu.	Qu.	Deliqueſ. ſalt.	Inſoluble combination.
Vegetable alkali.	Soluble ſalt. Cryſtallizable ?	Cryſtalliz. ſalt. Of difficult ſolution. Inſoluble in ar. ſpirit.	Cryſtallized ſalt.	Deliqueſ. ſalt. Soluble in ar. ſpirit.	Cryſtalliz. ſalt, nearly inſol. in cold water, but ſol. in 8 p. boiling water.
Mineral alkali.	Soluble ſalt.	Cryſtalliz. ſalt. Very ſoluble in water. Inſoluble in ar. ſpirit.	Cryſtall. ſalt.	Deliqueſcent ſalt. Sol. in ar. ſpirit.	Cryſtalliz. ſalt, nearly inſol. in cold water, but ſol. in 5 p. boiling water.
Volatile alkali.	Soluble ſalt ?	Soluble ſalt. Not cryſtalliz.	Cryſtall. ſalt.	Deliqueſ. ſalt.	Salt with exceſs of acid ?

Acid of ants. Aqueous.	Pruſſian acid. Aeriform. Aqueous.	Acid of fat. Liquid, fuming.	Acid of the ſtone of the bladder. Concrete; ſparingly ſoluble; decompoſed by heat.	Acid of ſilk worms. Aqueous.	Metallic Acids. Of arſenic. ſoluble in 2 p. water. Of tungſten. inſol.
No action.	No action.	No action. Corrodes glaſs ?	No action.	No action.	No action ? ?
Permanent cryſtals, bitter taſte. Soluble in 8 p. water. Inſoluble in ar. ſp.	Combination aqueous. Teſt liquor for iron.	Permanent cryſtals. Very ſoluble in water. Inſoluble in ar. ſp. 85 earth. 15 acid and water ?	Combination of ſparing ſolubility.	Qu.	Arſenical ſalt. Cryſtalliz. Tungſten. inſoluble. 2 earth. 1 acid or calx.
Combination difficultly effected.	No direct action. Nor indirect ? ?	Aſtringent maſs. Not cryſtalliz. Earth. Acid. Alkali ? ?	Qu.	Qu.	Arſenical coagulum.
Salt of difficult ſolubility ? Effloreſcent ? Inſoluble in ar. ſp.	Combination by a very weak action.	Gum-like maſs. Not cryſtallizable. 8 earth. 2 acid and water.	Qu.	Qu.	Arſenical coagulum.
Permanent cryſtals, bitter taſte. Soluble in 4 p. water. Inſoluble in ar. ſp.	Solution of a very ſmall portion of the earth.	Qu.	Qu.	Qu.	Arſenical ſalt. Of diffic. ſolub. ?
Deliqueſcent cryſtals.	Pure pruſſiated alkali. Cryſtallizable. With exceſs of acid ? Common pruſſian alkali, or lixivium ſanguinis; contains more or leſs of iron in combination.	Permanent cryſtals. Segner's ſalt. Inſoluble in ar. ſp.	Yellow ſolution. Not cryſtallizable ? ?	Qu.	Arſenical ſalts. Soluble in water. Cryſtall. with exceſs of alkali. Tungſtenic combin. Soluble with exceſs of alkali.
Foliated deliqueſ. cryſt. Soluble in 2 p. water.	Cryſtallizable ſalt.	Cryſtalliz. ſalt. Deliqueſcent ? ?	Solution. Cryſtalliz. ?	Qu.	Arſenical neutral ſalt. Cryſtals. Tungſtenic ?
Extremely deliqueſcent cryſtals.	Saline compound. Cryſtallizable ? Riſes entire by diſtillation; Without decompoſition ?	Cryſtalliz. ſalt. Sublimable without decompoſ. ?	Solution. Alkali much. Acid little.	Qu.	Arſenical ſalt. Cryſtalliz. Tungſtenic ſalt. Cryſtals with exceſs of alkali.

TABLE II. CONTINUED. *Compounds conſiſting in*

Component Parts.	Vegetable alkali.	Mineral alkali.	Volatile alkali.	Vitriolic acid.	Sulphureous acid.
Calx of Gold. Yellow metal, but green by tranſmitted light, or when fuſed; very malleable and tenacious; not calcinable by fire; does not ruſt. Specific gravity 19,3.	No direct action. Solution of precipitate from acid ?	As the vegetable alkali.	No direct action on the metal. Precipitates from acid, and combines with it. Fulminating gold.	No action on the metal. Slight action after previous diſtil. of the acid from manganeſe. Precipitates by F. alkali. Soluble but weakly retained.	No action ?
Calx of Platina. White metal malleable, very difficult of fuſion, does not ruſt; capable of welding. Specific gravity 22,0. Or 24,0 ?	No direct action. Throws down a precipitate from acid, conſiſting firſt of a triple cryſtal. ſalt, and next of a calx.	No direct action. Precipitates a calx from acid.	No direct action. Precipitates from acid ſimilar to the vegetable alkali.	No action ? Precipitate from nitro-muriatic ſolution.	No action.
Calx of Silver. White metal, very malleable, ſcarcely calcinable by furnace, does not ruſt; becomes black from ſulphur. exhal. Specific gravity 10,5.	No direct action.	No direct action.	No direct action. Combination with the calx precip. from nitrous a. by lime water. Cryſtalliz. fulmin. ſilver. Extremely dangerous.	Calcination by boiling and ſparing ſolution. Small cryſtals.	Qu.
Calx of Mercury. White metal, ſolid, and mall. when cooled below—39°; fluid in all higher temp. boils and riſes without decomp. at 600°; cal. in a mod. heat, and red. without ad. by a greater heat. Specific gravity 12,6.	Qu.	Qu.	Qu.	Solution by heat, moſtly ſeparated in form of white calx. Cryſtals, vitriol of mercury. Both the calx and the cryſ. become yellow by waſh. off the ac. with b. water. Turbith mineral.	Qu.
Calx of Tin. Yellowiſh white metal. Malleable, fuſible at 410°; calcinable, does not ruſt, acidifiable. Specific gravity 7,3.	Qu.	Qu.	Qu.	Solution and ſeparation of calx, eſpecially if the acid be concent. and hot. Cryſtals, by cooling.	Qu.
Calx of Copper. Reddiſh brown metal; hard; ſonorous malleable; tenacious, fuſible by ſtrong heat, burns with blueiſh green flame; partly vol. by ebul; cal. and liable to ruſt.	Combin. in the dry way ? In the humid way aſſiſted by the air, Slight combination or corroſion.	As the vegetable alkali.	Sparing ſolution by the aſſiſtance of air and water. Cryſtals. Indirect combin. with precipitates.	Solution in boiling concent. acid. Cryſtal. after dilution. Sol. in 4 p. water. 27 copper. 30 acid ? 43 water ?	Qu.
Calx of Lead. Blue white metal; ſoft; malleable; fuſible at 540 degrees; boils, and perhaps riſes in cloſe veſſels; calcinable. Slightly ruſts. Specific gravity 11,3.	In the dry way combination. In the humid way corroſion and ſolution.	As the vegetable alkali ?	Qu.	Solution and calcination. Cryſtals. Sol. in 18 p. water. Or more ?	Qu.
Calx of Iron. Gray white metal; hard; elaſtic; malleable; tenacious; very difficult of fuſion; becomes ignited by blows; weldable; magnetic; calcinable; very liable to ruſt. Specific gravity 7,8.	Combin. with the calx by fuſion. In the humid way, calcination and combin.	As the vegetable alkali ?	Combination.	Solution with heat if concentrated, but in the cold if diluted. Efflor. cryſtals. 25 iron. 20 acid ? 55 water ?	Qu.

Nitrous acid.	Marine acid.	Aerated marine acid.	Nitro muriatic acid.	Phoſphoric acid.	Aerial acid or fixed air.
Exceedingly ſparing ſolution of the metal. Precipitates by ſ. alkali. Soluble, but weakly retained.	No action. Precipitates by ſ. alkali. Sol. but weakly retained.	Solution with efferveſcence. Cryſtals. deliqueſ.	Solution with efferveſcence. Cryſtals, deliqueſ. Containing marine acid only ?	In the dry way by fuſion purple combination. In the humid way no action on the metal. Reduces and precipitates from acid ſol.	No action. Indirect combination ?
No action.	No action.	Solution as with the nitro muriatic acid.	Solution very dark yellow or brown red. Cryſtals, red, very ſparingly ſoluble.	No direct action. Reduction and precipitation from acid ?	No action. Qu. indirect.
Rapid ſolution. Cryſtals. Lunar nitre, or lunar cauſtic, when fuſed. Soluble in water and in $2\frac{1}{2}$ ar. ſp. Extrication and decompoſition of the acid by heat.	Very ſparing ſolution ? Precip. from nitrous acid. Luna cornea. Fuſible. Soluble in about 1000 p boiling water.	Solution and precipitation of luna cornea.	Solution and precipitation of luna cornea.	No direct action. Acts on the calx or precipitate ?	No action. Indirect comb. by precipitation.
Rapid ſolution. Cryſtals. Mercurial nitre. If heat be employed the quantity taken up is greater, and water throws down a yellow calx, reſembling turbith mineral.	No direct action. Takes it from the nitrous ſolution, and falls down in the form of cor. ſub. or calomel, as the mercury was more or leſs calcined.	Solution. Cryſtals. Corroſive ſublimate. Sparingly ſoluble in water, and in ar. ſp.	Solution and precip. ? Corroſ. ſublimate ?	No action. Precipitation from nitr. acid.	No direct action. Indirect comb. by precipitation.
Very rapid ſolution ; moſt part calcined and precipitated. No cryſtals. Production of volatile alkali.	Solution. Permanent cryſtals.	Solution without efferveſcence. Permanent cryſtals. Indirect comb. by diſtilling amalgam with corroſive ſub. Liquor of Libavius. Becomes ſolid with water.	Solution. The phenomena differ much according to the proportion and concentration of the acids, and the quantities of metal added at a time.	Corroſion of the metal and ſlight ſolubility of the calx.	No direct action. Indirect comb. by precipitation.
Rapid ſolution, ſome calx falls down. Cryſtals, by ſlow evap. Soluble in 4 p. water ? And in 4 p. ar. ſp.	Solution in concent. and boiling acid. Cryſtals.	Solution.	Solution.	Slight action on the metal. Aſſiſted by the air ?	No direct action ? Indirect comb. by precipitation. And ſolut. ?
Calcination, if concentrated. Solution, if more dilute. Cryſtals.	Calcination and partial ſolution. Cryſtals. Indirect combination. Corneous lead. Inſol. in water ?	Qu.	Qu.	Slight corroſion. Precipitation from nitrous acid ? And from ſugar of lead.	No direct action. Indirect comb. by precipitation. And ſolut.
Solution. Depoſition of calx. No cryſtals.	Solution. Magma. and deliqueſcent cryſtals.	Solution.	Solution.	Solution with efferveſcence. Cryſtalliz. or magma ? Compound depoſited by the addition of water. Siderite.	Solution. Separates in the form of an ochreous film. Alſo indirect comb. by precipitation.

TABLE II. CONTINUED. *Compounds conſiſting in*

Component Parts.	Acid of Borax.	Acid of Fluor.	Acid of Amber.	Acetous acid.	Acid of Tartar.
Calx of Gold.	No action either dry or humid; Nor indirect ? Colour of the metal ſaid to be changed by fuſion.	No action on the metal. Precipitate diſſolved.	Qu.	No direct action on metal. Metallic precipitat. from ſolution. Precipitates by alkalis diſſolved.	No action on the metal. Solution of precip.
Calx of Platina.	No action.	Qu.	No action on the metal. Indirect ?	No direct action on metal. Precipitates by alk. diſſolved.	No action on the metal. Solution of precip. ?
Calx of Silver.	No action ?	No action on the metal. Partial ſolution of precipitate.	Solution of precipitate. Cryſtals.	No action on the metal. Precipitates by alk. diſſolved with heat, cryſtallizable.	Solution of precip.
Calx of Mercury.	No direct action on the metal either dry or humid. Saturated borax throws down a yellow compound from nitrated mercury.	No action on the metal. Indirect combination. Solution of precipitate.	Solution of precipitate. Cryſtals ? ?	No action on the metal. Calces and alſo precipitates diſſolved. Shining cryſtals.	Imperfect combination, or Ethiops. Precipitates from nitrous ſol. Other indirect combinations.
Calx of Tin.	Sparingly combinable in the dry and humid ways. White cryſtals.	No action on the metal. Gelatinous ſolution of precipitate.	Solution of precipitate. Cryſtalliz.	Slight ſolut. of the metal, not cryſtalliz. Precipitates and calces by deflagration are ſoluble. Cryſtals. Salt of Tin.	No action on the metal. Indirect action ?
Calx of Copper.	Combination by fuſion. Weak action by heat in the humid way. Saturated borax precipitates all acid ſolutions of copper. The compound is green, and almoſt inſoluble.	Solution. Blue cryſtals.	Solution of the metal by long digeſtion. Cryſtalliz.	Sol. with vital air. Cryſtals of Verdigriſe. With more calx. Common Verdigriſe.	Little action on the metal. Acts on the calces. Precipitates vitriolic and marine ſolutions. Blue cryſtals, or Brunſwick green.
Calx of Lead.	Fine greeniſh Glaſs by fuſion of 1 p. acid and 2 p. minium. No humid action, but borax throws down this metal from acids.	Solution of the calx. Sweetiſh taſte. No cryſtals, but a powder depoſ. by evapor.	No action of the metal. Indirect combin. Solution of precip. Cryſtalliz.	Solution cryſtalliz. Sweet taſte. Sugar of lead. With more calx. Ceruſe.	Precipitation from nitrous or marine acid. Solution of calces ? ?
Calx of Iron.	Soluble compound by fuſion. Amber coloured ſolution with water; cryſtalliz. Borax precipitates this metal from acids, and its acid diſſolves the precipitates.	Strong action on the metal, and alſo its calces. No cryſtals, but hard maſs by evapor.	Slight action on the metal. Solution of precip. Cryſtalliz.	Slight action on the metal. Solution deliqueſ. cryſtals. Acid decompoſed by diſtil. or extricated ?	Solution of the metal. Indirect combination by martial vitriol. Cryſtals.

Empyreumatic Acid of Tartar.	Acid of Sugar.	Acid of Galls.	Acid of Lemons.	Acid of Apples.	Acid of Benzoin.
Qu.	No action on the metal, nor its precip.	Precipitate in the metallic ſtate from acid ſolution.	No action. Indirect ?	Qu.	Qu. Indirect ?
Qu.	No action on the metal. Solution of precip. Yellow cryſtals.	No action ?	No action.	Qu.	Qu. Indirect ?
Precipitation from nitrous ſolution.	No action on the metal. Sparing ſolution of precip. Separates it from nitr. acid. White powder nearly inſol.	Gray metallic precipitate from acid ſolution.	No action.	Qu.	Qu. Indirect ?
Precipitation from nitrous ſolution.	No action on the metal. Unites with calx. White comp. ſparingly ſol. Separates from vitr. and nitr. ſolutions.	Orange coloured precipitate from acid ſolution.	No action. Separates a white powder from the acetous ſolution.	Qu.	Qu. Indirect ?
Qu.	Solution and calcination. Cryſtals. Calx eaſily ſoluble.	Qu.	No action.	Qu.	Qu. Indirect ?
Solution ?	Solution of metal and of calces. Light blue powder, inſol. but with exceſs of acid. Separates from vitr. nitr. and mar. ſolution.	Brown precipitate from acid ſolution.	No action.	Qu.	Qu. Indirect ?
Qu.	No ſolution of the metal Calces and precipitates are ſoluble. Cryſtals nearly inſol. Separates it from nitr. acet. and mar. acids. 55 lead. 45 acid ?	White precipitate from acetous ſolution.	No action. Separates a white powder from the acetous ſolution.	Qu.	Qu. Indirect ?
Solution ?	Solution with efferveſ. Cryſtals efloreſ. ſol. 45 iron. 55 acid, partly in exceſs.	Black precipitate from vitriolic ſolution. Ink ?	Solution.	Brown ſolution. No cryſtals.	Qu. Indirect ?

TABLE II. CONTINUED. *Compounds conſiſting in*

Component Parta.	Empyreumatic acid of wood.	Empyreumatic Acid of Sugar, &c.	Acid of Camphor.	Acid of milk.	Acid of ſugar of milk.
Calx of Gold.	Qu.	Solution of gold leaf, and alſo of the calx.	Qu.	No action.	No action ?
Calx of Platina.	Qu.	Qu.	Qu.	Qu.	Qu.
Calx of Silver.	Qu.	No action.	Qu.	No action.	No action ? Precipitate from nitrous ſolution.
Calx of Mercury.	Qu.	No action.	Qu.	No action.	No action ? Precipitate from nitrous ſolution.
Calx of Tin.	Qu.	Solution and corroſion.	Qu.	No action.	No action. Indirect ?
Calx of Copper.	Qu.	Solution. No cryſtals.	Qu.	Slow ſolution. No cryſtals.	No action. Indirect ?
Calx of Lead.	Qu.	Calcination of the metal. Solution of minium. Aſtringent cryſtals.	Qu.	Solution ſparing ?	No action ? Precipitate from nitrous ſolution.
Calx of Iron.	Qu.	Blood-red ſolution. Green cryſtals.	Qu.	Solution. No cryſtals.	No action. Indirect ?

Acid of Ants.	Pruſſian acid.	Acid of fat.	Acid of the Stone of the bladder.	Acid of Silk-worms.	Metallic acids.
No action.	Precipitate from acid ſolution by double affinity.	Solution of the metal, with the aſſiſtance of one-third nitrous acid, or by abſtraction from manganeſe. Calces or precip. diſſolved. Cryſtals. Separates it from aq reg.	Qu.	Qu.	No arſenical comb. White molybdenic precipitate from acid.
No action.	No combination direct. Nor indirect ?	Habitudes as with gold.	Qu.	Qu.	Arſenical comb. by double affinity. Yellow.
No action on the metal. Solution of the calces. Cryſtals.	Precip. by double affinity from nitrous ſolution. Brick-coloured powder.	Sparing ſolution. Precip. difficultly diſſolved. Separates it from nitrous acid.	Indirect ?	Qu.	Arſenical ſolution. ——— precipitate by ſingle and alſo by double affinity. Molybdenic precipitate from nitrous acid.
No action on the metal. Solution of the calces. Cryſtals. Reduces the calces ? ?	Precip. by double affinity from nitrous ſolution. White and yellow ?	Combination by repeated abſtraction. Precip. ſoluble. White precip. from ſolut. of cor. ſublim. Characteriſtic of this acid.	Indirect ?	Qu.	Arſenical combination direct, by diſtill. Inſoluble in water. Indirect combinations. Molybdenic precipitate from nitr. ſolution.
No action on the metal. Nor the calces ?	Precip. by double affinity from nitrous ſolution. Dark green or blue powder.	Combination or corroſion and partial ſolution. Deliqueſ. ſalt.	Indirect ?	Qu.	Gelatinous arſenical ſolution. ——— precipitate by double affinity. Brown molybdenic precipitate from mar. acid.
No action on the metal. Solution of the calces. Cryſtals.	Precip. by double affinity from nitrous ſolution. Dark-red powder.	Solution by heat. Deliqueſ. cryſtals.	Indirect ?	Qu.	Green arſenical ſolution. Blue molybdenic precipitate.
No action on the metal. Solution of the calces. Cryſtals.	Precip. by double affinity from nitrous ſolution. Greeniſh yellow powder. Becomes white.	Corroſion of the metal. Solution of calces. Sweetiſh ; ſoluble cryſtals ?	Indirect ?	Qu.	Arſenical combin. by diſtill. Molybdenic precipitate from nitr. ſolution.
Solution of the metal and of the calces. Cryſtals.	Precip. by double affinity from vitriolic or marine ſolution. Deep blue, or Pruſſian blue.	Solution Deliqueſ. cryſtals.	Indirect ?	Qu.	Gelatinous ſolution by acceſs of air. Brown molybdenic precipitate from mar. acid.

TABLE II. CONTINUED. *Compounds conſiſting in*

Component Parts.	Vegetable alkali.	Mineral alkali.	Volatile alkali.	Vitriolic acid.	Sulphureous acid.
Calx of Zinc.	In the dry way ? In the humid way ſparing ſolution. Indirect ?	As the vegetable alkali.	Sparing ſolution.	Solution in diluted acid. White cryſtals. Soluble in 2 p. water. 25 metal ? 32 acid ? 33 water ?	Qu.
Calx of Manganeſe.	In the dry way ſolution of the calx. Blue or green colour. Pellucid when leſs calcined in the mixture.	As the veg. alk. ?	Qu.	Solution of the metal. Moſt effectual with dilution. Cryſtals. If too much calcined inſol. unleſs inflam. matter be added.	Solution as with vitriolic acid and inflam. matter.
Calx of Nickel.	Sparing ſolution, yellow.	As the vegetable alkali ?	Blue ſolution.	Solution of the calx. Green cryſtals.	Qu.
Calx of Biſmuth.	Qu.	Qu.	Qu.	Calcination and ſolution.	Qu.
Calx of Antimony.	Dry combin. ? ?	Dry combin. ? ?	Qu.	Calcination and ſolution. Not cryſtalliz.	Qu.
Calx of Cobalt.	Dry combin. ? In the humid way ſparing ſolut. ? Solution of precipitate from nitr. acid.	As the veg. alk ?	Qu.	Difficult ſolution. Cryſtals.	Qu.
Calx of Arſenic.	Combin. with the calx. Gelatinous, deliqueſ.	Combin. with the calx. Cryſtal.	Qu.	Solution by heat. But total ſeparation of calx by cooling.	Qu.
Calx of Molybdena.	Combination when acidified. Small cryſtals.	As the vegetable alkali ?	Combination ?	Solution of the acid. Becomes thick and blue by cooling.	Qu.
Calx of Wolfram.	Combination with the calx.	Combination with the calx.	Combination with the calx. Cryſtals. Decompoſ. by heat.	No action.	No action ?

Nitrous acid.	Marine acid.	Aerated marine acid.	Nitro-muriatic acid.	Phoſphoric acid.	Aerial acid or fixed air.
Rapid combination with diluted acid. Cryſtals. Deliqueſ.	Rapid ſolution. No cryſtals.	Qu.	Qu.	Fetid gum-like ſolution. Not cryſtalliz. but by evap. and fuſion forms tranſparent glaſs.	Solution. Indirect comb. or precip. Dull white.
Solution with the leading phenomena as in vitr. acid. No cryſtals ? ?	Solution of the metal. Alſo the calx with eſcape of aerated marine acid. Cryſtals ; Deliqueſ ?	Solution as of the calx in marine acid.	Solution.	Slow ſolution of the calx. Indirect combin. by microcoſ. ſalt to an acid ſolution.	Solution. White pellicle.
Solution. Green deliqueſ. cryſtals.	Solution. Green deliqueſ. cryſtals.	Solution ?	Solution ?	Very ſparing action.	Indirect combin. by double affinity. Greeniſh.
Very rapid ſolution. Cryſtals, effloreſc. Water abſtracts the acid and throws down a white calx ; Magiſtery of biſmuth.	Solution by repeated abſtraction. Deliqueſcent cryſtals, or butter of biſmuth.	Qu.	Qu.	Solution.	Indirect. White precip.
Strong action. Calcination and ſolution. Deliqueſ. cryſtals.	Weak action. Solution. Deliqueſ. cryſtals.	As the nitro-muriatic ?	Rapid ſolution. Deliqueſ. cryſtals.	Qu.	Indirect ?
Solution. Deliqueſ. cryſtals.	Solution of the metal and of the calx. Reddiſh brown, but green while hot. Deliqueſ. cryſtals.	As the nitro-muriatic ?	Solution. Green while heated. Sympathetic ink.	Solution of calx.	Indirect combin. or precip. Greeniſh pale red.
Solution ; calcination, acidification, according to quantities, circumſtances and management.	Solution of regulus ? ?	Acidification ?	Solution of calx.	Solution of calx.	Indirect combin. or precip. ? ?
Acidifies the metal, but does not diſſolve the acid.	Solution of the acid.	Qu.	Qu.	Qu.	Qu.
No action ? Triple compound with exceſs of acid, and a portion of alkali ; Acid of tungſten ſo called.	Inſoluble.	Qu.	Qu.	Qu.	Qu.

Component Parts.	Acid of Borax.	Acid of Fluor.	Acid of Amber.	Acetous Acid.	Acid of Tartar.
Calx of Zinc.	Light green ſlag by fuſion with the calx. Turbid ſolution. cryſtalliz ?	Strong action on the metal and its calces. Cryſtals ?	Ready ſolution of the metal. Solution of precip. Cryſtalliz.	Solution. Magma. Cryſtalliz. after dilution. By heat ſlight fulmination; blue flame; decompoſ. of acid.	Ready ſolution. Salt of ſparing ſolubility.
Calx of Mangane∫e.	Qu.	Salt of difficult ſolution which impedes the progreſs of the acid. Indirect combination by fluorated vol. alk. and acid ſolut.	Qu.	Very difficult ſolution. Deliqueſ. ſalt.	Solution. If heated decompoſ. of part of the acid with efferveſ. Cryſtal.
Calx of Nickel.	Qu.	Gelatinous ſolution of calx. Green cryſtals.	Combination and partial decompoſition of the acid.	Solution. Green cryſtals.	Qu.
Calx of Biſmuth.	White tranſparent glaſs by fuſion of the humid compound. No direct humid action, but borax gives a white powder from the ſol. in mixt. of vit. and marine acids.	No action on the metal. Solution of calx. No cryſtals, but a powder ſeparated.	Solution of the metal with heat. Solution of precip. Cryſtalliz.	Bitter acrid ſolution. Not cryſtalliz.	Cryſtalline precipitate from nitrous ſolution.
Calx of Antimony.	Qu. dry way. Precip. by borax from the reguline ſolution is ſoluble by this acid.	No action.	Little action on the metal. Solution of precip.	Very ſparing ſolution.	No action on the metal. Solution of calces.
Calx of Cobalt.	Imperfect combin. by fuſion. Precip. from acid by borax.	No action on the metal. Solution of calx.	Qu.	Pale roſe-coloured ſolution. Cryſtalliz. ?	Qu.
Calx of Arſenic.	Combination with the calx either in the humid or dry way. Soluble in water. Cryſtallizable.	Solution of calx. Small cryſtals.	Qu.	Regulus not ſol. Calx ſoluble with heat. Decompoſition or change in the acid ?	Qu.
Calx of Molybdena.	Qu.	Qu.	Qu.	No action ?	Qu.
Calx of Wolfram.	Qu.	Qu.	Qu.	Change of colour in the calx to blue. No ſolution ?	Qu.

Empyreumatic Acid of Tartar.	Acid of Sugar.	Acid of Galls.	Acid of Lemons.	Acid of Apples.	Acid of Benzoin.
Qu.	Combination with violent efferveſcence. White powder, inſol. in water unleſs acid in exceſs. 3 metal. 1 acid. Precip. from vitr. nitr. and mar. acid.	No action on the metal ? No precip. from ſolution in an acid.	Solution. Fine cryſtals.	Solution. Fine cryſtals.	Qu.
Qu.	Solution. White pulverulent precip. unleſs acid in exceſs. Precipitates cryſtals from vitr. nitr. or mar. ſolutions.	No action, or precipitate from acid.	Solution with partial decompoſ. of the acid if heated.	Qu. Decompoſition with calx?	Qu.
Qu.	Greeniſh combination. Nearly inſoluble. 1 metal. 2 acid. Precipitates from vitr. nitr. and mar. ſolutions.	Qu.	Qu.	Qu.	Qu.
Qu.	Corroſion of the metal ; Solution of the calx. White powdery ſalt, nearly inſolub. 1 metal. 1 acid. Precip. cryſtals from nitr. ſolution.	Orange yellow precipitate from an acid ſolution.	Qu.	Qu.	Qu.
Qu.	Slow ſolution with exceſs of acid. Cryſtalline grains ſcarce ſoluble. Precip. from acetous and vitr. ſolutions.	Qu.	Qu.	Qu.	Qu.
Qu.	Solution. Roſe-coloured powder if neutral, ſcarce ſoluble. Cryſtals with much exceſs of acid ; eaſily ſol. Precipitate of the roſe-coloured powder from every known acid.	No action, nor precip. from acid ſolution.	Qu.	Qu.	Qu.
Qu.	Solution of white calx. Cryſtals with exceſs of acid ; ſoluble in water; and in ar. ſp. ? ? Sublimed by gentle heat, decompoſed by ſtronger.	No action nor precip.	Qu.	Qu.	Qu.
Qu.	Qu.	Indirect combination or precipitate from the marine ſolution. Dark brown. This was with the infuſion. With the acid no precip.	Qu.	Qu.	Qu.
Qu.	Qu.	Qu.	Qu.	Qu.	Qu.

Component parts.	Empyreumatic acid of wood.	Empyreumatic acid of ſugar.	Acid of camphor.	Acid of milk.	Acid of ſugar of milk.
Calx of zinc.	Solution. Cryſtalliz.?	Metal partly diſſolved; Greeniſh; partly calcined; greyiſh.	Solution.	Solution. Cryſtals.	Precip. by double affin. Inſoluble.
Calx of manganeſe.	Solution, with partial decompoſ. of acid ??	Qu.	Qu. ſolution.	Qu.	Precip. by double affin. Inſoluble.
Calx of nickel.	Qu.	Qu.	Qu.	Qu.	Precip. by double affin. Inſoluble.
Calx of biſmuth.	Qu.	Qu.	Solution.	No action.	Precip. by double affin. Inſoluble.
Calx of antimony.	Qu.	Greeniſh ſolution.	Qu.	No action.	Precip. by double affin. Inſoluble.
Calx of cobalt.	Qu.	Qu.	Solution.	No action.	Precip. by double affin. Inſoluble.
Calx of arſenic.	Qu.	Qu.	Solution. Of the regulus?	Qu.	Precip. by double affin. Inſoluble.
Calx of molybdena.	Qu.	Qu.	Qu.	Qu.	Precip. by double affin. Inſoluble.
Calx of wolfram.	Qu.	Qu.	Qu.	Qu.	Precip. by double affin. Inſoluble.

Acid of ants.	Pruſſian acid.	Acid of fat.	Acid of the ſtone of the bladder.	Acid of ſilk-worms.	Metallic acids.
Conſiderable action and ſolution. Cryſtals.	Indirect combination or precipitate from nitrous acid. Reddiſh yellow, becomes whitiſh.	Copious ſolution.	Indirect combin. ?	Qu.	Arſenical ſolution of the metal. Inſoluble combination defends the reſidue In the dry way combination and exploſion. Indirect combination humid.
Qu.	Indirect combin. or precipitate. Dirty blueiſh gray.	Copious ſolution.	Indirect combin. ?	Qu.	Arſenical ſolution. Cryſtals. Indirect arſenical combin. by double affinity.
Green ſolution of the calx. Deep green cryſtals; hemiſpherical radiated; ſcarcely ſoluble in water unleſs an acid be preſent.	Indirect combination or precipitate from nitrous acid. Dirty reddiſh yellow.	No direct action. Solution of precip.	Indirect combin. ?	Qu.	Very ſlight direct action by arſenical acid. Indirect combination by double affinity.
Solution of the calx. Cryſtals.	Indirect combination or precipitate from nitrous acid. Reddiſh yellow.	No action on metal. Solution of precip.	Indirect combin. ?	Qu.	Arſenical ſolution precipitable by water. In the dry way calcination: But not ſolution. Indirect combin. humid.
Solution of the calx?	Indirect combination or precipitate. Blue; eaſily diſſolved by exceſs. Green.	Solution by heat. Permanent cryſtals.	Indirect combin. ?	Qu.	Arſenical combination. Calcination and ſolution precipitable by water. In the dry way combination with inflam.
Solution of the calx.	Indirect combination or precipitate from nitrous acid. Blue; more gray than that of iron.	No action on metal. Precip. diſſolved.	Indirect combin. ?	Qu.	Sparing arſenical ſolution. Roſe-colour. Indirect combinations.
Solution of the calx.	Indirect combination or precipitate from marine acid or aqua regia. Green and yellow mixt.	Copious ſolution of the white calx. Cryſtals.	Indirect combin. ?	Qu.	
Qu.	Indirect combination or precipitate from the marine ſolution. Brown.	No action.	Indirect combin. ?	Qu.	Qu.
Qu.	No precipitate from the nitrous or acetous ſolution.	Qu.	Indirect combin. ?	Qu.	Qu.

TABLE III. *Compounds of certain Products of Organization.*

Component Parts.	Fixed Alkalis.	Volatile Alkali.	Acids.	Ardent Spirit.	Sulphur and Phoſphorus.
Gum. Sol. in water ; afford oil when diſtilled with alkali. Turns ſour and putreſies. Deſtroyed by fire ; but ſcarcely inflam.	Coagulate the aqueous ſolution. No combin. ?	As fixed alkali ?	With nitrous acid by abſtraction affords acid of ſugar.	Inſoluble. Precipitable from water. Unchanged ?	Qu.
Fat oils. Inſol. in water. Do not riſe by the water bath. Inflam. when boiling. Under theſe claſs wax ? Spermaceti ? Caoutchouc ? ?	Soap. Diffuſible in water and ſeparable on the filtre ? Soluble in ar. ſp. Heavier than oil and difficultly burned.	Imperfect ſoap.	Decompoſition of both and partial combination.	Inſoluble.	Solution. Balſam of ſulphur.
Volatile oils. Inſol. in water. Riſe in diſtill. on the water bath. Inflammable. Under theſe aroma or ſp. rector ? ? camphor? ?	Imperfect ſoap.	Imperfect ſoap.	Imperfect combin. if weak. Combuſtion with ſtrong nitrous acid.	Solution.	Solution.
Reſins. Inſol. in waetr. Decompoſed in diſtill. Very combuſtible. Moſtly ſoluble in fat oil. Under theſe lac ?	Soap.	Soap ?	More or leſs of combuſtion, or an equivalent proceſs.	Solution.	Combination ?
Starch. Not ſoluble in cold water, but combinable with heat. More inflammable than gum.	Qu.	Qu.	With nitrous acid abſtracted. Acid of ſugar.	Qu.	Qu.
Sugar. Very ſoluble in water, cryſtallizes by cooling Combuſtible.	Solution ? ?	Solution.	Solution. With nitrous acid abſt. Acid of ſugar.	Solution In 12 parts heated. Very ſparingly cold.	Qu.
Vegetable gluten. Abſorbs water and is then inſoluble in it. Small maſſes dry and become brittle, larger putrefy. Burns like animal matters.	Solution by heat precipitable by acids.	As fixed alkali ?	Solution with decompoſition. By abſtraction of nitrous acid. Acid of ſugar.	No Action ? Extracts the water ?	Qu.
Animal mucilage or glue. Soluble in water, fluid when hot, thick and adheſive when cold, may be boiled without alteration.	Solution. With decompoſ.?	Solution ? With decompoſ.	Solution. With decompoſ.	No action ? Precipitates from water ?	Qu.
Serum. Soluble or diffuſible in cold water. Coagulates and becomes inſoluble by heat of 167° Fahrenheit. Said not to differ from curd and white of egg.	Solution and greater fluidity. Qu. decompoſition ?	Solution.	Coagulation, Not ſoluble in water.	Coagulation. Soluble in water.	Qu.

TABLE of the Correſpondence of the Thermometers of Fahrenheit, Reaumur, and Celſius.

Fahr.	Reaum.	Celſi.	Fahr.	Reaum.	Celſi.	Fahr.	Reaum.	Celſi.	Fahr.	Reaum.	Celſi.
212	80.0	100	159	56.4	70.5	106	32.8	41.1	53	9.3	11.6
211	79.5	99.4	158	56	70	105	32.4	40.5	52	8.8	11.1
210	79.1	98.8	157	55.5	69.4	104	32	40	51	8.4	10.5
209	78.6	98.3	156	55.1	68.8	103	31.5	39.4	50	8	10
208	78.2	97.7	155	54.6	68.3	102	31.6	38.8	49	7.5	9.4
207	77.7	97.2	154	54.2	67.7	101	30.6	38.3	48	7.1	8.8
206	77.3	96.6	153	53.7	67.2	100	30.2	37.7	47	6.6	8.3
205	76.8	96.1	152	53.3	66.6	99	29.7	37.2	46	6.2	7.7
204	76.4	95.5	151	52.8	66.1	98	29.3	36.6	45	5.7	7.2
203	76	95	150	52.4	65.5	97	28.8	36.1	44	5.3	6.6
202	75.5	94.4	149	52	65	96	28.4	35.5	43	4.8	6.1
201	75.1	93.8	148	51.5	64.4	95	28	35	42	4.4	5.5
200	74.6	93.3	147	51.1	63.8	94	27.5	34.4	41	4	5
199	74.2	92.7	146	50.6	63.3	93	27.1	33.8	40	3.5	4.4
198	73.7	92.2	145	50.2	62.7	92	26.6	33.3	39	3.1	3.8
197	73.3	91.6	144	49.7	62.2	91	26.2	32.7	38	2.6	3.3
196	72.8	91.1	143	49.3	61.6	90	25.7	32.2	37	2	2.7
195	72.4	90.5	142	48.8	61.1	89	25.3	31.6	36	1.7	2.2
194	72	90	141	48.4	60.5	88	24.8	31.1	35	1.3	1.6
193	71.5	89.4	140	48	60	87	24.4	30.5	34	0.8	1.1
192	71.1	88.8	139	47.5	59.4	86	24	30	33	0.4	0.5
191	70.6	88.3	138	47.1	58.8	85	23.5	29.4	32	0	0
190	70.2	87.7	137	46.6	58.3	84	23.1	28.8	31	0.4	0.5
189	69.7	87.2	136	46.2	57.7	83	22.6	28.3	30	0.8	1.1
188	69.3	86.6	135	45.7	57.2	82	22.2	27.7	29	1.3	1.6
187	68.8	86.1	134	45.3	56.6	81	21.7	27.2	28	1.7	2.2
186	68.4	85.5	133	44.8	56.1	80	21.3	26.6	27	2.2	2.7
185	68	85	132	44.4	55.5	79	20.8	26.1	26	2.6	3.3
184	67.5	84.4	131	44	55	78	20.4	25.5	25	3.1	3.8
183	67.1	83.8	130	43.5	54.4	77	20	25	24	3.5	4.4
182	66.6	83.3	129	43.1	53.8	76	19.5	24.4	23	4	5
181	66.2	82.7	128	42.6	53.3	75	19.1	23.8	22	4.4	5.5
180	65.7	82.2	127	42.2	52.7	74	18.6	23.3	21	4.8	6.1
179	65.3	81.6	126	41.7	52.2	73	18.2	22.7	20	5.3	6.6
178	64.8	81.1	125	41.3	51.6	72	17.7	22.2	19	5.7	7.2
177	64.4	80.5	124	40.8	51.1	71	17.3	21.6	18	6.2	7.7
176	64	80	123	40.4	50.5	70	16.8	21.1	17	6.6	8.3
175	63.5	79.4	122	40	50	69	16.4	20.5	16	7.1	8.8
174	63.1	78.8	121	39.5	49.4	68	16	20	15	7.5	9.4
173	62.6	78.3	120	39.1	48.8	67	15.5	19.4	14	8	10
172	62.2	77.7	119	38.6	48.3	66	15.1	18.8	13	8.4	10.5
171	61.7	77.2	118	38.2	47.7	65	14.6	18.3	12	8.8	11.1
170	61.3	76.6	117	37.7	47.2	64	14.2	17.7	11	9.3	11.6
169	60.8	76.1	116	37.3	46.6	63	13.7	17.2	10	9.7	12.2
168	60.4	75.5	115	36.8	46.1	62	13.3	16.6	9	10.2	12.7
167	60	75	114	36.4	45.5	61	12.8	16.1	8	10.6	13.3
166	59.5	74.4	113	36	45	60	12.4	15.5	7	11.1	13.8
165	59.1	73.8	112	35.5	44.4	59	12	15	6	11.5	14.4
164	58.6	73.3	111	35.1	43.8	58	11.5	14.4	5	12	15
163	58.2	72.7	110	34.6	43.3	57	11.1	13.8	4	12.4	15.5
162	57.7	72.2	109	34.2	42.7	56	10.6	13.3	3	12.8	16.1
161	57.3	71.6	108	33.7	42.2	55	10.2	12.7	2	13.3	16.6
160	56.8	71.1	107	33.3	41.6	54	9.7	12.2	1	13.7	17.2

ADDITIONS.

Acid of Tartar, Empyreumatic.

ACID OF TARTAR, EMPYREUMATIC. By the diſtillation of cream of tartar, an aqueous acid is afforded, which has been called ſpirit of tartar. It has a very pungent ſmell, and cannot eaſily be rectified a ſecond time on account of the ſudden production of elaſtic fluid, which burſts the veſſels. Its combinations have been little inquired into. It forms with the fixed alkalis cryſtallizable ſalts, which are ſoluble in cold water.

Charcoal.

CHARCOAL. I. The firſt analytical experiments in proof of the decompoſition of fixed air were made by Mr. Tennant, and are inſerted in the eighty-firſt volume of the Philoſophical Tranſactions. He applied phoſphorus to red hot marble, and obtained charcoal, phoſphoric acid, and lime. Dr. Pearſon, in Part II. of the Tranſactions for 1792, makes ſome judicious obſervations on the action of the affinities in this experiment, which led ſeveral chemiſts to ſuſpect, that the ſmall quantity of charcoal might have pre-exiſted in the phoſphorus, which is in fact obtained by diſtillation with that ſubſtance. And for this reaſon he made experiments, by heating phoſphorus in contact with other ſubſtances. The mild foſſil alkali, cleared of its water of cryſtallization by previous heating, was in the quantity of eight hundred grains preſſed down upon two hundred grains of tranſparent phoſphorus, in a thick white glaſs tube, about one inch in diameter, and three feet and a half long, coated at the part containing the alkali. Heat ſufficient to ſoften the tube was then applied to the coated part, and in this ſtate the end containing the phoſphorus was gradually drawn over the fire and kept ignited for twenty minutes. By the ſublimation of the phoſphorus, and its contact with the ignited ſalt, part of the carbonic acid, or fixed air, was decompoſed and deprived of its vital air, leaving charcoal, its other component part, behind. Of this, by ſolution and filtration, he obtained 32,4 grains, which he examined by combuſtion, by deflagration with nitre, by reduction of lead, and by the diſtillation of phoſphorus from its acid. It was indubitably charcoal. Very ſatisfactory examinations were alſo made by the Doctor of every one of the other products and reſidues, which ſhewed that the carbonic acid had been truly decompoſed.

Similar experiments were made by the application of phoſphorus to mild vegetable alkali, and alſo to the calcareous, ponderous, magneſian, and argillaceous earths. The Doctor does not give the detail of the reſults, or indeed ſpeak with preciſion of the quantities of the products; but he thinks the concluſion may be admitted, that the carbonic acid, combined with any of theſe ſubſtances, will be decompoſed at a due degree of heat. He could not decompoſe it with the volatile alkali; neither in fact could this be expected, from the known circumſtance, that charcoal itſelf ſeparates the phoſphoric acid from that body.

Phoſphorus applied in Dr. Pearſon's method to quick-lime afforded no charcoal, but an hepatic compound, exploſive by a gentle heat, which emitted bubbles of phoſphoric air when thrown into cold water, and theſe exploded as uſual when they arrived in contact with the air of the atmoſphere. Neither did cauſtic alkali afford charcoal, except a minute quantity ariſing from the carbonic acid, of which that alkali cannot be totally cleared. The vitriolic and marine combinations with the fixed alkalis did not afford any charcoal.

II. The abſorption of elaſtic fluids, ſlightly mentioned under the Article CHARCOAL, is a ſingular fact very difficult to be accounted for. The fluids ſeem to be merely condenſed, and not combined. Does the charcoal abſorb that heat which before maintained the elaſtic ſtate?

This diſcovery, firſt made by the Abbe Fontana, was afterwards purſued and extended by various other eminent chemiſts. The Count Morozzo, in the Journal de Phyſique for April 1783, relates a ſeries of experiments made to aſcertain the quantities of air thus abſorbed by equal volumes of charcoal paſſed into a tube containing the elaſtic fluid over mercury. The ignited coal was plunged into the mercury, and aroſe into the tube, of which the length above the mercury was 12 inches. The abſorptions are expreſſed in inches and lines.

	In.	L.
Of atmoſpheric air abſorbed	3	6
Fixed	11	0
Alkaline	8	8
Nitrous	6	10
Inflammable	2	1
Vital from red precipitate	2	2
—— from nitre	1	11
—— from water	2	1
Atmoſpheric air vitiated		
By the combuſtion of a taper	3	8
———— of ſulphur	3	9
By the mutual action of ſulphur and iron filings moiſtened	3	6
By the reſpiration of ſmall animals	3	4

III. Mr. Lowitz and after him other chemiſts have obſerved a remarkable property in charcoal, by which it purifies various mucilaginous ſaline and other bodies. This is amply ſhewn under the article VINEGAR. The following general paper is extracted, with very little abridgment, from the ſecond volume of the Engliſh Tranſlation of Crell's Journal.

1. Common vinegar when boiled in a matraſs with charcoal powder becomes perfectly limpid. 2. Terra foliata tartari could never be rendered white with this colourleſs vinegar; but, to effect this, vinegar that has been previouſly diſtilled muſt be uſed. 3. When honey diluted with water is boiled with charcoal powder, a very unpleaſant ſmell is produced. 4. When the neceſſary quantity of charcoal powder is added to hydromel, the liquor runs through the filter as clear as water. 5. The reſiduous charcoal powder, when lixiviated with a large quantity of water, renders the water of a ſemi-pellucid black colour. 6. If this black water be evaporated, the black matter will be depoſited on the ſides of the veſſel in the form of a very ſoft and unctuous powder. 7. An ounce of gum arabic boiled with 30 lbs. of charcoal powder and ſufficient water, was entirely loſt in the proceſs, either by decompoſition or abſorption. 8. Fluids which

contain either vegetable mucilage or animal gluten, will not run clear through the filter without the addition of charcoal powder. 9. Beer, milk, and lemon-juice, when diluted with a prodigious quantity of water, and mixed with a ſufficient quantity of charcoal powder, remain of a turbid black colour. 10. Hence it follows, that the charcoal powder may be advantageouſly uſed in the ſeparation of oily, gummy, mucous or gelatinous matter. 11. The charcoal powder which remained after the purification of a mother-ley of phlogiſticated alkali rendered the water with which it was lixiviated of a beautiful bright green colour. 12. Charcoal powder over which a very empyreumatic diſtilled vinegar that had been concentrated by freezing had been abſtracted till the charcoal was become dry, diſplayed upon its ſurface all the colours of a peacock's tail. 13. Charcoal powder over which ſome common vinegar that had been frozen had been diſtilled with a ſtrong heat, when mixed with water, ran over the ſides of the glaſs jar in which the mixture was made, with a thick froth. 14. Glaſs veſſels and other utenſils may be purified from long retained ſmells, by rinſing them out well with charcoal powder. 15. Honey perfectly pure may be obtained from the ſcum of clarified honey, by diluting it with water, and adding to it while upon the fire a proper quantity of charcoal powder. 16. Charcoal has no effect upon the bitter taſte of ſalt water. 17. Salt of hartſhorn is rendered uncommonly white, when triturated with an equal quantity of charcoal powder, and put into a retort for diſtillation ſo as to fill it half way up. 18. A large quantity of acid of tartar treated with charcoal powder, was brought to the point of cryſtallization in ſeventeen hours, and was afterwards found to be perfectly limpid and free from empyreuma. 19. Common ardent ſpirit purified by charcoal without diſtillation, is always found to be of a blackiſh turbid appearance, when too little of the powder is added. But this black matter may be inſtantly ſeparated from the ſpirit by the addition of a ſufficient quantity of dry ſalt of tartar, which dephlegmates the ſpirit. 20. When three pounds of oil of hartſhorn were mixed with two pounds of charcoal powder, and put into a cucurbit, a little dark brown oil aſcended at the laſt part of the proceſs. 21. When no charcoal was added, the operation was finiſhed with a gentle heat in twelve hours, and the obtained oil was not inferior to the former either in quantity or quality. 22. The extraordinary property which charcoal poſſeſſes of attracting the ſtrongeſt part of vinegar, and not giving it out in diſtillation, has been already noticed in the article VINEGAR. 23. When a glaſs funnel was filled with charcoal coarſely pounded and riddled, and a few pounds of the black concentrated liquor which remains after the diſtillation of Hoffman's anodyne drops, poured upon it, this black acid in the courſe of two months was rendered perfectly colourleſs. 24. By rubbing and waſhing out the mouth and teeth thoroughly with fine charcoal powder, the ſmell of bad breath may be remedied. 25. Putrid ſtinking water was immediately deprived of its offenſive ſmell by means of charcoal powder, and rendered tranſparent. 26. When the acid of ants was mixed with charcoal powder, it was found to be of a dark turbid appearance, and did not begin to come clear till ſix months had elapſed. 27. On ſaturating ſix pounds of the ſame acid of ants with purified pot-aſh, it was conſtantly of a dark turbid appearance, and yet it ran through four folds of blotting paper as readily as pure water. 28. On diſtilling the acid of ants with a great quantity of charcoal powder, that which came over towards the end of the diſtillation was of a brown colour and empyreumatic. The reſiduum contained in the retort was ſtrongly caked together, and imparted a very deep brown colour to water. 29. The bad ſmell of putrid urine is taken away by mixing charcoal powder with it while boiling; and the reſiduum when lixiviated with water, affords a liquor as clear as water, and which when evaporated to the point of cryſtallization was fluid enough to allow the ſalts which it contained to ſhoot into beautiful white cryſtals of cubical and other forms. 30. Charcoal powder deprives pure alkali, when ſaturated with the colouring matter of Pruſſian blue, of its yellow colour. 31. Charcoal without the aſſiſtance of heat rendered a watery ſolution of liver of ſulphur colourleſs and inodorous. On adding oil of vitriol to the ſolution, precipitation and the ſmell of hepatic air enſued after ſome hours had elapſed. 32. A ſolution of liver of ſulphur deprived of its colour by charcoal when evaporated to dryneſs yielded a perfectly white ſaline reſiduum, which being laid upon burning charcoal entered into a red fuſion, without ſhewing any mark of ſulphur: and a ſolution of the ſame ſubſtance evaporated to dryneſs without charcoal, gave a blackiſh ſaline reſiduum, which upon being laid on heated charcoal broke out into a blue flame, and emitted a ſtrong ſulphureous ſmell. 33. When a ſmall quantity of a balſam of ſulphur prepared with ſome eſſential oil, is diſſolved in highly rectified ſpirit of wine, and afterwards mixed with charcoal powder, the ſmell of the eſſential oil alone remains. 34. Neither the watery nor ſpirituous ſolution of ſoap is changed by treatment with charcoal. 35. Camphor and its odour are not in the leaſt altered by charcoal; yet when this laſt is added to a ſolution of unrefined camphor in ſpirit of wine, it deprives the ſame of its yellow colour. 36. When a ſufficient quantity of charcoal is added to a ſaturated ſolution of camphor in highly rectified ſpirit of wine, the camphor will ſhoot into plumous cryſtals, which, accordingly as the weather is warmer or colder, will alternately diſappear and re-appear. 37. On ſtrongly boiling cream of tartar and charcoal powder with water, the whole of the cream of tartar became cryſtallized in regular, large, flat, tranſparent cryſtals, entirely different in their figure from the common cryſtals of this ſalt. 38. In the above-mentioned experiment tartariſed calcareous ſalt was alſo cryſtallized among the charcoal powder, in the form of roundiſh tranſparent polygons, of a remarkably beautiful golden colour. 39. From four ounces of a very brown oily ſalt of amber well triturated with two pounds of fine charcoal powder, and put into a large retort, not quite a dram of ſalt of amber was collected, that was as white as ſnow and almoſt inodorous. This ſalt could not be converted into acid of ſugar. 40. Flowers of benzoin obtained by ſublimation are rendered uncommonly white and ſhining when treated with charcoal powder. Under this purifying treatment the oil of benzoin comes over as clear and colourleſs as water; but by length of time becomes yellow again. 41. Acid of apples is entirely deſtroyed or decompoſed by digeſtion with charcoal, ſo that nothing remains but mere water, with a very little extractive matter of the nature of a neutral ſalt. 42. Honey when boiled with charcoal after the ſeparation of the charcoal powder recovers the brown colour which it loſt at firſt. 43. By trituration with charcoal powder bugs (cimices) were entirely deprived of their bad ſmell. 44. The ſtrength of ſpirits diſtilled from malt is increaſed by the mere addition of charcoal. 45. This increaſe of ſtrength was aſcertained by comparative experiments of ſpecific gravity; and of dephlegmation as well by ſalt of tartar as by diſtillation. It ſeems to be in ſome meaſure doubtful, whether this proceſs might be advantageouſly ſubſtituted inſtead of thoſe at preſent in uſe. Mr. Lowitz thinks it may, and relates various experiments with obſervations to that effect. He remarks that ardent ſpirit completely purified by charcoal has a fine ſmell, exactly reſembling that of peaches. Does this fact bear any relation to the fire damp of coal mines which ſmells of peach-bloſſoms, and probably conſiſts of ſome modification of fixed and inflammable air? 46. Vinegar is not weakened by diſtillation with charcoal, but too large a quantity appears to decompoſe it, as is the caſe with ardent ſpirit in the like circumſtances. 47. The acid of wood obtained by diſtillation from lignum vitæ, or guaiacum, when diſtilled with charcoal was very readily purified from the great quantity of empyreumatic oil which adheres to it: and a true glacial vinegar was obtained by concentrating it to a very high degree. 48. From two ounces of charcoal powder mixed with eight ounces of ſmoking ſpirit of nitre, three ounces ſix grains of ſmoking acid, of a very beautiful dark green colour were obtained. 49. On pouring eight ounces more of freſh ſmoking ſpirit of nitre to the reſiduous charcoal powder, after it was become cold, a quantity of ignited ſparks ſuddenly appeared in the retort which broke in pieces, whilſt the charcoal took fire, but without detonation. 50. The experiment with eight ounces of ſmoking ſpirit of nitre and two ounces of charcoal powder was again repeated in the ſame way as No. 48. When the diſtillation was over, the reſiduous charcoal powder was ſomewhat ſhining in its upper part, but not much caked or agglutinated. In order to ſee whether it had ſuffered any alteration from this firſt operation, Mr. Lowitz ſubjected very ſmall quantities of it to the following trials:

(a) When thrown upon burning charcoal it did not produce the ſlighteſt detonation, nor did it give out any ſmell.

(b) Applied to the tongue, it did not give out any ſaline taſte.

(c) From a diluted brown lixivium of acid of tartar it extracted all the colour in the courſe of five minutes without the aſſiſtance of heat; whence it appears that it had not yet loſt its dephlogiſticating power.

(d) The affuſion of ſmoking ſpirit of nitre upon it was followed by an extrication of heat, but not by inflammation. 51. This charcoal powder, which did not yet ſeem to have undergone the leaſt alteration, Mr. Lowitz put again into the retort; he then mixed together the acid liquors (whoſe ſpecific gravity was 1,325, and whoſe concentration amounted to twenty-nine degrees) obtained in the diſtillations No. 50 and No. 48, and poured them upon the charcoal. After this ſecond diſtillation to dryneſs, the ſpecific gravity of the obtained liquor was found to be 1,317, and its concentration twenty degrees. 52. After the third diſtillation, the ſpecific gravity amounted only to 1,417, and the concentration to only fourteen degrees. The charcoal powder did not even yet ſhew the leaſt ſigns of ſolubility. 53. As the diſtilled liquor was now become very weak, Mr. Lowitz employed in the fourth diſtillation nine ounces of common nitrous acid, the ſpecific gravity of which was 1,258, and its concentration equal to twenty-four degrees. At the end of the operation he found the ſpecific gravity of the diſtilled liquor to be 1,226. The reſiduous charcoal powder was now become very ſtrongly caked and full of cracks. 54. After the fifth diſtillation he did not find any difference in the ſpecific gravity of the acid. A ſaline ſublimate was contained in the neck of the retort. 55. After the ſixth diſtillation, the acid whoſe ſpecific gravity was ſtill 1,222 appeared of a yellow colour. The reſiduum had now a ſhining black appearance, like pitch; on pouring upon it ſome of the diſtilled liquor, a reddiſh-brown ſolution was obtained. 56. After the ſeventh diſtillation the acid became ſtill yellower, and its ſpecific gravity was now reduced to 1,218. The reſiduum was now for the moſt part ſoluble in water. 57. Charcoal thus reduced to the form of an extract is as

ſoluble in highly rectified ſpirit of wine as it is in water. 58. A ſufficiently diluted ſolution of this ſubſtance in water is entirely deprived of its colour and bitter taſte by freſh charcoal powder. 59. The watery ſolution of the extract of charcoal when thoroughly evaporated in a ſand bath, ſwells up at the laſt and becomes perfectly dry; but it ſoon attracts moiſture again by expoſure to the air. However, when left to the air for ſome months, it loſes this deliqueſcent property, and its humidity is gradually dried up. 60. Reſin of jalap was rendered extremely pure and colourleſs by repeated addition of charcoal to the ſpirituous ſolution, and ſubſequent diſtillation of the menſtruum. The loſs amounted to half the weight of the reſin. 61. Common reſin appeared to require ſo much charcoal for its purification, that Mr. Lowitz abandoned the attempt. 62. Ether which is tainted with a ſulphureous ſmell is not deprived of this ſmell by charcoal powder. On the other hand, water that has been impregnated as much as poſſible with ſuch kind of ether, immediately loſes this ſmell when charcoal powder is mixed with it. 63. Charcoal powder has not the leaſt effect upon the ſtrong-ſmelling ſubſtance which is extricated during the diſtillation of ſuet and of olive oil. 64. Reſins and native balſams diſſolved in ſpirit of wine are deprived of their colour, but not of their peculiar ſmell, by charcoal powder. 65. The ſmell of diſtilled or eſſential oils is not at all affected by charcoal. 66. All empyreumatic oils, except oleum philoſophorum, are entirely deprived of their colour and ſmell by charcoal. 67. If as much charcoal be added to diſtilled waters as is ſufficient to deſtroy the ſmell, the water will always remain turbid; but when a larger quantity of charcoal powder is added, the water becomes perfectly clear and tranſparent. 68. Charcoal powder not only deprives diſtilled waters of their ſmell, but alſo water impregnated with any ſort of empyreumatic oil. 69. A watery infuſion of aſafœtida and a cold infuſion of Virginia ſnake-root and valerian were entirely deprived of their ſmell by charcoal powder. 70. Charcoal powder produces no effect when mixed with empyreumatic oils. 71. In like manner the eſſential oils ſuffer no loſs of ſmell from the admixture of charcoal powder. 72. The admixture of charcoal with a watery ſolution of opium deprives it of its peculiar ſmell. 73. Both white and red wine are rendered colourleſs by charcoal powder. 74. Charcoal powder produces no change in the common eſſence of orange-peel. 75. On the other hand it deprives eſſence of wormwood both of its colour and ſmell. 76. Both the ſpirituous and watery tinctures of ſaffron are in like manner completely deprived of their colour and ſmell. 77. The ſpirituous and watery tinctures of red ſaunders, cochineal, and gum-lac, are alſo rendered quite colourleſs. 78. Charcoal powder completely ſeparates all the calcareous particles from lime-water. 79. Water ſaturated with fixed air is very ſpeedily deprived of the ſame by charcoal powder. 80. If a little dry charcoal be introduced into a bottle filled with inflammable air, on applying the flame of a candle to the mouth of the bottle, an exploſion will be produced, which proves that it muſt have received ſome pure air from the charcoal powder. 81. Water impregnated with hepatic air is freed from the ſame by means of charcoal powder. 82. Onions and garlick, after they have been well bruiſed or maſhed, are quickly deprived of their ſtrong ſmell by mixture with charcoal powder. 83. Mr. Lowitz found that the coaly reſiduum after the preparation of dulcified ſpirit of nitre, and alſo the coaly matter which remains behind after the diſtillation of Hoffman's anodyne liquor, are equally as proper for the dephlogiſticating proceſſes as charcoal itſelf. 84. Mr. Lowitz obſerves, as a remarkable circumſtance, that he has ſucceſsfully employed the thoroughly edulcorated coaly matter which remains after the diſtillation of Hoffman's liquor, before it has undergone calcination, to deprive a lixivium of acid of tartar of its yellow colour.

The tranſlator of the papers of Mr. Lowitz, in the Engliſh Chemical Journal, adds the following remarks and information in a note which I have not at all abridged.

In the 4th No. of the Chemical Annals for 1791, Mr. Lowitz has pointed out the principal circumſtances upon which, after an experience of four years, he has found the ſucceſs of the dephlogiſticating proceſſes with charcoal to depend. To a want of information in theſe particulars are to be aſcribed the failure and diſappointment complained of by many chemiſts who have repeated his experiments. The circumſtances ſo neceſſary to the ſucceſs of theſe operations are reduced to two general heads; viz.

I. The preparation and quality of the charcoal.

II. The mode of employing the charcoal, according to the different nature of the ſubſtances to be operated upon. This comprehends whatever relates to

(a) Bringing the ſubſtances to be purified, to a ſtate proper for being acted upon by the charcoal.

(b) Adding the charcoal in due proportion.

(c) Adding it at a proper time.

(d) The ſeparation of the charcoal powder from the purified ſubſtances; and laſtly,

(e) The further treatment of the liquid ſubſtances after the ſeparation of the charcoal powder.

I. With regard to the preparation of the charcoal, it is abſolutely neceſſary to deprive it of all its oily matter by making it red-hot throughout its whole ſubſtance. Charcoal that has been badly burnt gives out its oily empyreumatic parts, and at the ſame time a brown colour, even to water, much more to ſaline leys when boiled therewith. No wonder then, that liquors which are heated with ſuch imperfect charcoal, inſtead of being made colourleſs, ſhould even become browner than they would be without ſuch treatment.

For the ſpace of nearly a year after he firſt diſcovered the purifying property of charcoal, Mr. Lowitz uſed to be guided, in the ſelection of what he wanted for the dephlogiſticating proceſſes, merely by outward appearance and lightneſs. But as in this uncertain mode of proceeding ſome badly burnt charcoal was uſually picked out along with the good, his experiments ſometimes proved abortive. He afterwards took the precaution of making the charcoal red-hot throughout; and ſince that time (viz. for the laſt three years) he has always accompliſhed his end.

1. The charcoal muſt be made quite red-hot in a furnace, and thoſe pieces which ceaſe to give out any ſmoke muſt be taken out with tongs, and be laid to cool upon clean bricks. Leſt the larger lumps ſhould not have undergone a red heat throughout, and there ſhould ſtill remain a little phlogiſtic or empyreumatic matter in the heart or middle of them, it will be proper to break them into ſmaller pieces before they are taken out of the fire; for a ſingle lump of ſuch imperfectly charred coal would counteract or deſtroy, if not altogether at leaſt in part, the dephlogiſticating effect of the reſt of the charcoal powder with which it ſhould chance to be mixed.

2. In the next place, great care muſt be taken that during the cooling the charcoal do not come into contact with any greaſy, oily, or other inflammable body; for the ſmoke which would thus be produced, would be abſorbed by the

charcoal, and render it unfit for the dephlogiſticating proceſſes. For the ſame reaſon, the preſence of much ſmoke (in whatever way produced) in the place where the charcoal is prepared, would be highly prejudicial.

3. As ſoon as the charcoal is become cool, the aſhes which adhere to it muſt be carefully blown off with a pair of bellows; it muſt then be pounded and paſſed through a fine hair ſieve, and kept for uſe in clean earthen or glaſs veſſels, cloſely ſtopped, in order to keep out the air.

4. Much depends on the fineneſs of the charcoal powder; for the finer it is, the greater number of acting ſurfaces are preſented to the ſubſtances to be operated upon, and conſequently a ſmaller quantity of the powder ſuffices. By an attention to this circumſtance, a good deal of trouble and labour may be ſaved.

5. The goodneſs of charcoal powder, thus prepared, may be eaſily and quickly aſcertained by a ſmall trial, in the following manner: Put an ounce of the moſt empyreumatic and worſt kind of ardent ſpirits into a phial, and add thereto about a couple of drams of the powder; then ſhake the whole well together. If the charcoal powder is of a proper quality, the ardent ſpirits will immediately loſe their bad ſmell.

II. Reſpecting the mode of employing the charcoal, it is to be remarked that a given quantity of charcoal powder attracts only a limited quantity of inflammable matter, after its ſaturation with which it becomes incapable of any further action.

Hence, when any ſubſtance is to be dephlogiſticated, it is better to add too much than too little charcoal powder; for in the firſt caſe the end will be accompliſhed, whilſt in the latter there will be only a partial dephlogiſtication, or perhaps none at all.

And yet too great an exceſs of charcoal muſt not be employed; for, not to mention that the proceſs is thus rendered much more troubleſome, the ſubſtances that are operated upon are thereby in danger of being decompoſed.

(a) All ſolid bodies that are to be purified by charcoal (except ſuch as admit of being treated in the dry way, by ſublimation) muſt be previouſly brought into a fluid ſtate by diſſolution in their proper menſtrua, from which the undiſſolved and groſſer parts muſt be afterwards ſeparated by filtration.

Nor is it enough that the ſubſtance to be purified be barely diſſolved in its proper menſtruum; it is further requiſite that its ſolution be duly diluted either with water or ſpirit of wine, according to the nature of the diſſolved ſubſtance.

In ſome caſes where an empyreumatic oil, or ſlimy matter, adheres too ſtrongly to the ſubſtance to be purified, it is neceſſary to boil the fluid along with the charcoal powder even to dryneſs, and to re-diſſolve it afterwards, and this for ſeveral ſucceſſive times, till the purification is completed.

(b) To find out the proper quantity of charcoal powder in operations in the large way, add it little by little to the liquor during the boiling, until it ſhall be found, by repeatedly taking out ſmall portions and filtrating and examining them, that the liquor is become ſufficiently pure.

To as much acid of tartar as is obtainable from 30lbs. of cryſtals of tartar, we are directed to add ſix ounces of charcoal powder, beginning to add ſome of it as ſoon as the liquor is ſet to evaporate, and continuing the addition till the acid is brought almoſt to the point of cryſtallization. In this way 96lbs. of acid of tartar, in the higheſt degree of purity, and of a perfectly white appearance, were prepared from 300lbs. of cream of tartar.

In the diſtillation of vinegar, Mr. Lowitz adds 10 or 12lbs. of charcoal powder to 150lbs. of vinegar, and diſtills to dryneſs in the open fire. Here the receiver muſt be frequently changed towards the end of the diſtillation, ſince there generally comes over at the laſt, when the charcoal powder is employed in this proportion, about 6 or 8lbs. of brown empyreumatic vinegar, which, however, may be afterwards purified by a ſimilar diſtillation with freſh charcoal powder.

A terra foliata tartari, of a ſnowy whiteneſs, may be obtained by adding, during the boiling, from four to ſix ounces of charcoal powder to the product from about 5lbs. of ſalt of tartar, ſaturated with vinegar previouſly diſtilled with charcoal in the manner before mentioned.

(c) Dry volatile ſalts, ſuch as flowers of benzoin, ſalt of amber, ſalt of hartſhorn, &c. ſhould be triturated with an equal quantity of charcoal powder, put into a retort, and covered over to about a hand's breadth with coarſe charcoal powder. In the caſe of acid ſalts, the proportion of charcoal powder muſt not be too great; otherwiſe a conſiderable loſs will be occaſioned.

In the purification of ardent ſpirits, the following is the ſafeſt way of proceeding: After the ſpirit is put into the ſtill, the charcoal muſt be added little by little, till it is found, by frequently taking out ſmall quantities and diluting them with a little hot water, that all the burnt or empyreumatic ſmell is gone off; then, and not before, we are to proceed to diſtillation.

In the caſe of ſalts, which by evaporation without charcoal powder conſtantly become brown and empyreumatic, the charcoal powder muſt remain mixed therewith, till they are brought quite, or at leaſt very near to the point of cryſtallization.

(d) The ſeparation of the charcoal powder is eaſieſt and ſooneſt effected by means of a linen ſtrainer. When no more of the liquor will run through of itſelf, the remainder muſt be ſqueezed out as well as poſſible, and after it has been paſſed through a freſh filter, and is become quite clear, it may be mixed with the former liquor.

That nothing may be loſt, the charcoal powder which remains upon the filter may be lixiviated with water; but there are very few caſes in which this laſt weak lixivium can be added to the former liquors; it muſt be previouſly evaporated by itſelf, and undergo the other ſubſequent treatment.

A principal rule to be obſerved is, to ſtrain the liquors that are boiled with charcoal as hot as poſſible; for they are then in the moſt fluid ſtate, and conſequently the ſeparation of the fine particles of charcoal takes place more readily.

(e) After the ſeparation of the charcoal powder, thoſe lixivia that are liable to be affected by the fire muſt be evaporated only with the gentleſt heat.

In all the experiments with charcoal, in which any compariſon is made, in reſpect to ſpecific gravity, ſmell, taſte, or colour, between the liquors before and after the operation, it is neceſſary to keep in mind what was added for their due dilution before the treatment with charcoal, and to make allowances accordingly.

If, in the firſt attempt to deprive any ſubſtance of its colour by means of charcoal powder, the operator ſhould not ſucceed, he muſt not immediately conclude that charcoal is incapable of producing ſuch an effect upon that ſubſtance. The ſolution might not have been diluted ſufficiently. Before any concluſion is drawn, it is neceſſary that the ſolution be diluted to an extreme degree (ſo, however, as to let the colour be ſtill diſcernible), and that the charcoal powder be added in the largeſt poſſible quantity. Should no alteration then take place, he may ſafely pronounce that the colour of the ſubſtance thus tried, is not affected by charcoal.

Heat is not always required in experiments with charcoal. Cold admixture, aſſiſted by agitation, ſhould be firſt tried; if this ſhould not ſucceed, recourſe muſt be had to digeſtion and boiling.

There are caſes in which, notwithſtanding the preſence of ſuch parts as are actually attracted by charcoal, its uſe would, in other reſpects, be improper. In theſe inſtances, therefore, before any operations in the large way are attempted, a trial in the ſmall way ſhould be made.

Gums.

GUMS. The celebrated Rouelle, in his Courſe of Chemiſtry, remarked, that the acid of gummy matters, when expoſed to deſtructive diſtillation, acts upon their oil, and converts it into coaly matter; whence they afford merely water, acid, and a very ſmall quantity of oil, which is thick, and does not paſs through the filter. Mr. Woulfe, in a ſhort paper inſerted in the Journal de Phyſique for May 1788, gives an account of the diſtillation of gum arabic with one fourth of its weight of the vegetable fixed alkali. This combines with the acid, and accordingly none comes over, but the quantity of oil is conſiderable, and it is ſufficiently attenuated to paſs through the filtering paper. Honey, by the ſame treatment, affords oil copiouſly.

Nitre.

NITRE. The purification of nitre by means of charcoal, forms the ſubject of a paper by Mr. Gadolin, in the ſecond volume of Crell's Annals (tranſlated) of which the following is an abſtract:

1. The difference which takes place in the cryſtallization between nitre, common and digeſtive ſalt, and the deliqueſcent property of the earthy neutral ſalts, affords ſufficient means of ſeparating each kind of ſalt from the other; but this ſeparation is impeded when there is much unctuous matter in the mixture. 2. Hence the purification of crude nitre depends principally on the ſeparation of this ſubſtance. 3. The beſt method hitherto propoſed, of freeing the nitre from its unctuous matter, ſeems to have been the addition of alum. But this method is not only too expenſive, but there is reaſon to apprehend that the nitre may take up a portion of the vitriolic acid. 4. Mr. Gadolin undertook to purify nitre by charcoal powder, and relates the following experiments. 5. He put twelve pounds of very brown and moiſt crude nitre into a veſſel, and found that a dark brown fluid had collected at the bottom of the veſſel, amounting to about five ounces and a half. This he ſeparated, and calls the mother-ley. 6. Four ounces of the nitre ſpread out upon bibulous paper, and dried in a moderate temperature of the air, weighed 7,15 half-ounces. 7. Half an ounce of crude nitre diſſolved in water, gave, with a ſolution of ſilver, 0,0496 half-ounce of dry luna cornea. 8. Two ounces and a half of the crude nitre, diſſolved in water, and ſuperſatured with vegetable alkali, gave a ſmall quantity of a dark brown precipitate. 9. Half an ounce of the mother-ley gave, with a ſolution of ſilver, 0,368 half-ounce of luna cornea. On filtering and evaporat-

ing the ley, a quantity of tranſparent priſmatic cryſtals were produced. 10. From one ounce of the mother-ley precipitated by means of the vegetable-alkali, 0,092 half ounce of a coloured powder was obtained. The marine acid diſſolved this powder with violent effervescence. The vitriolic acid effervefced in like manner with the precipitate, and left a conſiderable quantity of undiſſolved gypſum in a powdery ſtate. This ſolution, when evaporated, afforded ſelenitic needles, and cryſtals of Epſom ſalt. 11. One ounce of the mother-ley evaporated to dryneſs by a gentle heat, left behind a dark brown maſs, which was full of irregular cubic cryſtals, and weighed 0,625 half-ounce. 12. On ſmartly boiling for ten minutes, three ounces of the mother-ley, with four ounces of water, and three-fourths of an ounce of charcoal, the charcoal acquired an increaſe of one-fourth of an ounce in its weight. 13. Hence it follows that 100 parts of the crude ſaltpetre, which Mr. Gadolin employed, contained nearly 9$\frac{1}{2}$ per cent. of mother-ley, and three-ſevenths more of marine acid than the ſame quantity of mother-ley. Again, according to experiment 7th, 100 parts of crude nitre contain as much marine acid as 4-96 parts of luna cornea; and according to experiment 9th, in 9$\frac{1}{2}$ parts of mother-ley, there was only as much marine acid as in three-fifth parts of luna cornea. 14. From experiments eleven and twelve it follows, that the ingredients in 100 parts of unrefined ſaltpetre were about 89 parts of pure nitre, three parts of muriated neutral ſalts, one part of unctuous matter, and ſix parts and a half of water, without reckoning the water of cryſtallization. 15. Mr. Gadolin being convinced of the poſſibility of purifying nitre by means of charcoal, made various experiments in order to aſcertain what proportion of charcoal powder the ſaltpetre requires, and what phænomena would preſent themſelves in the proceſs. The proof of the abſence of unctuous matter was aſcertained by the facility of cryſtallization, and the greater quantity of cryſtals afforded; and the purity of the nitre was ſhewn by the teſt of the nitrous ſolution of ſilver. The reſults were according to the following Table:

	Crude nitre.	Charcoal powder.	Cryſtallized nitre.	Luna cornea, from a quarter of an ounce of the cryſtallized nitre.	Luna cornea, from 100 parts of cryſtallized nitre.	Luna cornea, from the lixivium, to 100 parts of pure nitre.
	Half ounces.	Half ounce.	Half ounce.	Half ounce.	Parts.	Parts.
1	32	2,5	19,5	0,0009	0,18	5,5
2	24	2,5	21,	0,0011	0,22	3,
3	24	2,5	20,9	0,0013	0,26	13,
4	24	2,5	20,4	0,0017	0,34	16,
5	24	2,5	22,25	0,0025	0,50	20,
6	24	2,5	20,	0,0018	0,36	24,
7	24	2,5	21,5	0,0020	0,40	27,
8	0	1,	6,75	0,0070	1,4	90,
9	0	0	2,5	0,179	35,8	300,

From the preceding Table Mr. Gadolin obſerves, that we may ſee how little diſpoſed the muriated ſalts are to unite with the nitre, when the lixivium is freed from its unctuous matter, and the cryſtallization is properly conducted: and that ſince the mother-ley is rendered fit for cryſtallization by means of charcoal powder, there is reaſon to believe that charcoal powder might be very advantageouſly employed by the ſaltpetre makers in the firſt boilings of the impure ley. He adds, that in large purifications, much leſs than three-fourths of an ounce of charcoal powder to a pound of nitre, will, in all probability, be ſufficient. That if in large purifications, the unctuous matter ſhould be converted into ſcum, the charcoal powder will probably be ſeparated from the ley by the deſpumation; in which caſe filtration will be unneceſſary, and the expence attending this new proceſs will then be very trifling. But even though the filtration ſhould be found neceſſary, ſtill he is perſuaded that the expence, whatever it be, will be amply compenſated by the greater purity of the nitre, and by the ſuperior quality of the gunpowder prepared from it.

Spermaceti.

SPERMACETI. From the want of a correct table of reference to the Annales de Chimie, I did not diſcover the ſecond memoir of Fourcroy, containing a chemical examination of the fatty ſubſtance into which the dead bodies in the burying-pound Des Innocens was converted. The reader will find a detail of the facts under the article Spermaceti, where this ſubſtance is erroneouſly ſaid to be of the ſame nature as that animal product; a general opinion, founded as I ſuppoſe on the experiment mentioned in p. 865, and which may probably be true of ſuch animal matters as are thus converted actually under water. The memoir of Mr. Fourcroy is of conſiderable length, nearly ſixty pages, for which reaſon I ſhall not attempt to give a full account of every fact it exhibits, but ſhall ſelect the leading facts as conciſely as poſſible.

1. This ſubſtance is fuſed at a leſs degree of heat than that of boiling water, and may be purified by preſſure through a cloth, which diſengages a portion of fibrous and bony matter. 2. The proceſs of deſtructive diſtillation by a very graduated heat was begun, but not completed on account of its tedioufneſs, and the little promiſe of advantage it afforded. The products which came over, were water charged with volatile alkali, a fixable oil, concrete volatile alkali, and no elaſtic fluid during the time the operation was continued. 3. Fragments of the fatty matter, expoſed to the air during the hot and dry ſummer of 1786, became dry, brittle, and almoſt pulverulent at the ſurface. On a careful examination, certain portions were obſerved to be ſemi-tranſparent, and more brittle than the reſt. Theſe poſſeſſed all the apparent properties of wax, and did not afford volatile alkali by diſtillation. 4. With water, this fatty matter exhibited all the appearances of ſoap, and afforded a ſtrong lather. The dried ſubſtance did not form the ſaponaceous combination with the ſame facility or perfection as that which was recent. About two-thirds of this dried matter, ſeparated from the water by cooling, and proved to be the ſemi-tranſparent ſubſtance reſembling wax. This was taken from the ſurface of the ſoapy liquor, which being then paſſed through the filter, left a white ſoft ſhining matter which was fuſible, and combuſtible. 5. Attempts were made to aſcertain the quantity of volatile alkali in this ſubſtance, by the application of lime and of the fixed alkalis, but without ſucceſs. For it was difficult to collect and appreciate the firſt portions which eſcaped, and likewiſe to diſengage the laſt portions. The cauſtic volatile alkali, with the aſſiſtance of a gentle heat, diſſolved the fatty matter, and the ſolution became perfectly clear and tranſparent at the boiling temperature of the mixture, which was at 185 degrees of Fahrenheit. 6. Vitriolic acid of the ſpecific gravity of

2,0 was poured upon ſix times its weight of the fatty matter, and mixed by agitation. Heat was produced and a gas or effluvium of the moſt inſupportable putreſcence was emitted, which infected the air of an extenſive laboratory for ſeveral days. Mr. Fourcroy ſays, that the ſmell cannot be deſcribed, but that it is one of the moſt horrid and repulſive that can be imagined. It did not however produce any indiſpoſition either in himſelf or his aſſiſtants. By dilution with water, and the ordinary proceſſes of evaporation and cooling properly repeated, vitriolic ammoniac and ſelenite were obtained. A ſubſtance was ſeparated from the liquor, which appeared to be the waxy matter ſomewhat altered by the action of the acid. 7. The nitrous and marine acids were alſo applied, and afforded phenomena worthy of remark, but which for the ſake of conciſeneſs are here omitted. 8. Strong ardent ſpirit does not act on this matter at the ordinary temperature of the air. But by boiling it diſſolves one third of its own weight, which is almoſt totally ſeparable by cooling, as low as 55°. The ſpirit after this proceſs affords by evaporation a portion of that waxy matter which is ſeparable by acids, and is therefore the only portion ſoluble in cold ardent ſpirit. The quantity of fatty matter operated on, was four ounces, or 2304 grains, of which the boiling ſpirit took up the whole except 26 grains, which proved to be a mixture of 20 grains of ammoniacal ſoap, and ſix or eight grains of the phoſphoric ſalts of ſoda and of lime. From this experiment, which was three times repeated with ſimilar reſults, it appears that ardent ſpirit is well ſuited to afford an analyſis of the fatty matter. It does not diſſolve the neutral ſalts; when cold, it diſſolves that portion of concrete animal oil of which the volatile alkali had flown off, and when heated it diſſolves the whole of the truly ſaponaceous matter, which is afterwards completely ſeparated by cooling. And accordingly it was found that a thin plate of the fatty matter, which had loſt nearly the whole of its volatile alkali by expoſure to the air for three years, was almoſt totally diſſolved by the cold ſpirit.

The concrete oily or waxy ſubſtance obtained in theſe experiments conſtitutes the leading object of reſearch, as being the peculiar ſubſtance with which the other well known matters are combined. It ſeparates ſpontaneouſly by the action of the air, as well as by that of acids. Theſe laſt ſeparate it in a ſtate of greater purity, the leſs diſpoſed the acid may be to operate in the way of combuſtion. It is requiſite therefore for this purpoſe, that the fatty matter ſhould be previouſly diffuſed in 12 times its weight of hot water; and the marine or acetous acids are preferable to the vitriolic and nitrous. The colour of the waxy matter is grayiſh; and though expoſure to the air, and alſo the action of the aerated marine acid, did produce an apparent whiteneſs, it nevertheleſs diſappeared by ſubſequent fuſion. No method was diſcovered by which it could be permanently bleached.

The nature of this wax, or fat, is different from that of any other known ſubſtance of the like kind. When ſlowly cooled after fuſion, its texture appears cryſtalline or ſhivery like ſpermaceti; but a ſpeedy cooling gives it a ſemitranſparency reſembling wax. Upon the whole, nevertheleſs, it ſeems to approach more nearly to the former than to the latter of theſe bodies. It has leſs ſmell than ſpermaceti, and melts at 127 degrees of Fahrenheit. Spermaceti required 6° more of heat to fuſe it. The ſpermaceti did not ſo ſpeedily become brittle by cooling as the other ſubſtance. One ounce of alcohol of the ſtrength between 39 and 40 degrees of Baumé's areometer, diſſolved when boiling-hot 12 gros of this ſubſtance, but the ſame quantity in like circumſtances diſſolved only 30 or 36 grains of ſpermaceti. The ſeparation of theſe matters was alſo remarkably different, the ſpermaceti being more ſpeedily depoſited, and in a much more regular and cryſtalline form. Volatile alkali diſſolves with ſingular facility, and even in the cold, this concrete oil ſeparated from the fatty matter ; and by heat it forms a tranſparent ſolution, which is a true ſoap. But no exceſs of volatile alkali can produce ſuch an effect with ſpermaceti.

M. De Fourcroy concludes his memoir with ſome ſpeculations on this change to which animal ſubſtances in peculiar circumſtances are ſubject. In the Modern Chemiſtry, ſoft animal matters are conſidered as a compoſition of the oxydes of hydrogene and carbonated azote, more complicated than thoſe of vegetable matters, and therefore more inceſſantly tending to alteration. If then the carbone be conceived to unite with the oxygene, either of the water which is preſent or of the other animal matters, and thus eſcape in large quantities in the form of carbonic acid or fixed air ; we ſhall perceive the reaſon why this converſion is attended with ſo great a loſs of weight, namely, about nine tenths of the whole. The azote, a principle ſo abundant in animal matters, will form ammoniac by combining with the hydrogene ; part of this will eſcape in the vaporous form, and the reſt will remain fixed in the fatty matter. The reſidue of the animal matters deprived of a great part of their carbone, their oxygene and the whole of their azote will conſiſt of a much greater proportion of hydrogene, together with carbone, and a minute quantity of oxygene. This, according to the theory of M. De Fourcroy, conſtitutes the waxy matter which, in combination with the ammoniac, forms the animal ſoap into which the dead bodies are thus converted.

ERRATA.

Page 6, line 22, for excepting that *they do*, read excepting that *it does.*—P. 13, l. 15, for *reſembles*, read *reſemble.*—P. 29, l. 45, for *grinding in a mortar*, read *grinding it in a mortar.*—P. 29, l. 50, for *till be water*, read *till the water.*—P. 40. l. 43. for ETHER NITROUS, read ETHER only.—P. 45, l. 15, for *liquid phoſphorcus*, read *liquid acid of phoſphorus.*—P. 101, l. 44, for *however but that men*, read *however that men.*—P. 104, l. 13, for *if not*, read *if it does.*—P. 125, l. 26, after FERMENTATION, read *alſo* PUTREFACTION.—P. 145, l. 42, for *have not as yet*, read *did not.*—P. 172. Mr. Morveau has ſince publiſhed ſome corrections of this table. They are, Ponderous earth and vitriolic acid 66. Ponderous earth and acetous acid 28. Marine acid and the following, viz. min. alk. 31; lime 24; vol. alk. 21; magneſia 22; argill. earth 18.—P. 193, l. 17, for *the beam will be*, read *the beam will weigh.*—P. 204, l. 11, for *lome*, read *lime.*—P. 228, l. 34, for *here* read *Bengal.*—P. 239, l. 9, for *were*, read *are.*—P. 267, l. 35, for *acid water*, read *acid, water.*—P. 290, l. 46, for *miply*, read *imply.*—P. 298, l. 23, for *they ſerve as intermedium*, read *for they ſerve as an intermedium.*—P. 309, l. 45, for *coloured*, read *calcined.*—P. 351, l. 16, for *a ſtate of perfection*, read *its ſtate of perfection.*—P. 351, l. 44, for *referrible*, read *referrable.*—P. 371, l. 48, for *or to that which cauſes it*, read *and to that which cauſes it.*—P. 373, l. 14, for *have been obſerved*, read *has been obſerved.*—P. 375, l. 9, for *that the expanſions*, read *ſhews that the expanſions.*—P. 398, l. 50, for PHLOGISTICS, read PHLOGISTON.—P. 406, l. 7, for *vita lair*, read *vital air.*—P. 416, l. 30, for *falls*, read *ſalts.*—P. 424, l. 24, for JELLY, read GELLY.—P. 428, l. 10, for *Bartholate*, read *Berthollet.*—P. 485, l. 14, for *precipitating*, read *precipitate.*—P. 587, l. 41 and 48, for *turgere*, read *tuyere.*—P. 627, l. 17, for *litruus*, read *litmus.*—P. 628, l. 17, after *grains*, dele *as we ſhall preſently find.*—P. 641, l. 33, for *maintained*, read *maintain.*—P. 642, l. 1, for *us then ſay, they*, read *us then, ſay they.*—P. 655, l. 10, for *reſinous*, read *urinous.*—P. 760, l. 6, for *latter*, read *fiery ſtream.*—P. 765, l. 30, for *Rork's*, read *Born's.*—P. 839, in the note, for *Keir*, read *Here.*—P. 851, l. 30, for ALKALINE, read ALKALI.—P. 983, l. 24, for *ſaid*, read *ſett.*

TO THE BINDER.

There are Five Plates, which are to be placed at the end.
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A.